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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

[redacted]

MSC INTERNAL NOTE MSC-CF-P-68-11

APOLLO ENTRY SUMMARY DOCUMENT

MISSION "C"

(SA-205, S/C-101)

FINAL COPY

PREPARED BY:

LAUNCH AND ENTRY PROCEDURES SECTION

FLIGHT PROCEDURES BRANCH

FLIGHT CREW SUPPORT DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

ENTRY SUMMARY DOCUMENT

MISSION C (AS-205/101)

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CONTENTS

ACCUM	Accumulator
ADR	Address
AMP	Amplifier
ANT	Antenna
BBA	Backup Bank Angle
BCN	Beacon
BEF	Blunt End Forward
BMAG	Body Mounted Attitude Gyro
CBN	Cabin
CDR	Commander
CDU	Coupling Data Unit
CMP	Command Module Pilot
CKT	Circuit
CMC	Command Module Computer
CMD	Command
COMM	Communications
CRYO	Cryogenic
CSS	Computer Subsystem
DAP	Digital Auto Pilot
DET	Digital Event Timer
DISCH	Discharge
DSKY	Display and Keyboard
ECA	Electronic Control Assembly
ECS	Environmental Control Subsystem
EMER	Emergency
EMS	Entry Monitor System
EPS	Electrical Power Subsystem
ESS	Essential
EVAP	Evaporator
EXCH	Exchange
FCSM	Flight Combustion Stability Monitor
FDAI	Flight Director Attitude Indicator
FWD	Forward
G	Gravity
G&C	Guidance and Control
GETI	Ground Elapsed Time of Ignition
GDC	Gyro Display Coupler
GLY	Glycol
GMBL	Gimbal
G&N, G/N	Guidance and Navi[illegible]on
GND	Ground
GPI	Gimbal Position Indicator
HA	Height of Apogee
HE	Helium
HP	Height of Perigee
HTR	Heater
IMP	Impulse
IMU	Inertial Measurement Unit
LDG	Landing
LEB	Lower Equipment Bay
LMP	Lunar Module Pilot
LV	Local Vertical
MAN	Manual
MESC	Master Event Sequence Controller

MGA	Middle Gimbal Angle
MK	Mark
MNVR	Maneuver
MON	Monitor
MTR	Motor
MTVC	Manual Thrust Vector Control
OPT	Option, Optics
ORIEN	Orientation
O2	Oxygen
P	Pitch
PGA	Pressure Garment Assembly
PGNCS	Primary Guidance, Navigation and Control System
PIPA	Pulse Integrating Pendulous Accelerometer
PLSS	Portable Life Support System
PRIM	Primary
PRPLNT	Propellant
PTT	Push to Talk
PWR	Power
R	Roll
R1,R2,R3	Register 1, 2, 3
RAD	Radiator
RCDR	Recorder
RCS	Reaction Control System
REL	Relief
RHC	Rotational Hand Controller
RNG	Range
RSI	Roll Stability Indicator
RTGO	Range to Go
SCS	Stabilization and Control System
SEC	Secondary
SECS	Sequential Events Control Subsystem
SEP	Separation
SEQ	Sequential
SM, S/M	Service Module
STBY	Standby
TB	Talkback Display
TBD	To Be Determined
TERM	Terminate
TF	Time from
TFF	Time of Freefall
THC	Translational Hand Controller
TIG	Time of Ignition
TK	Tank
TLM	Telemetry
TRNFR	Transfer
TVC	Thrust Vector Control
VDC	Volts Direct Current
VG	Velocity To Be Gained
VIO	Inertial Velocity
VLV	Valve
VM	Velocity Measured
Y	Yaw

1.0 INTRODUCTION

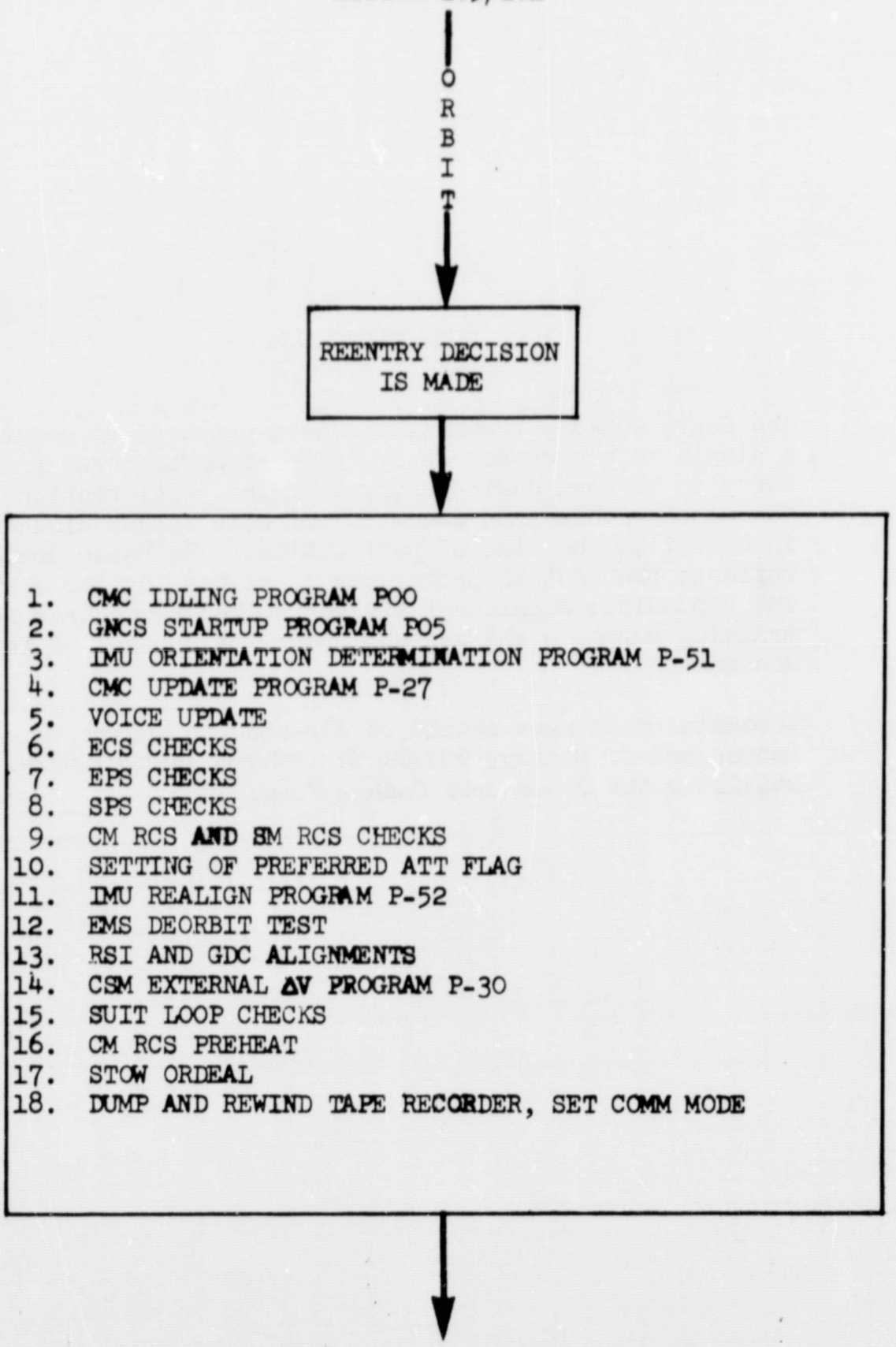
The Entry Summary Document has been prepared to provide a single reference source of information and crew procedures to be used during entry training. Information contained within this document reflects flight planning in effect at the time of publication. The basic document reflects the control procedures to be used by the crew. The appendices supplement the controlled procedures for training purposes and are not under the control of this document.

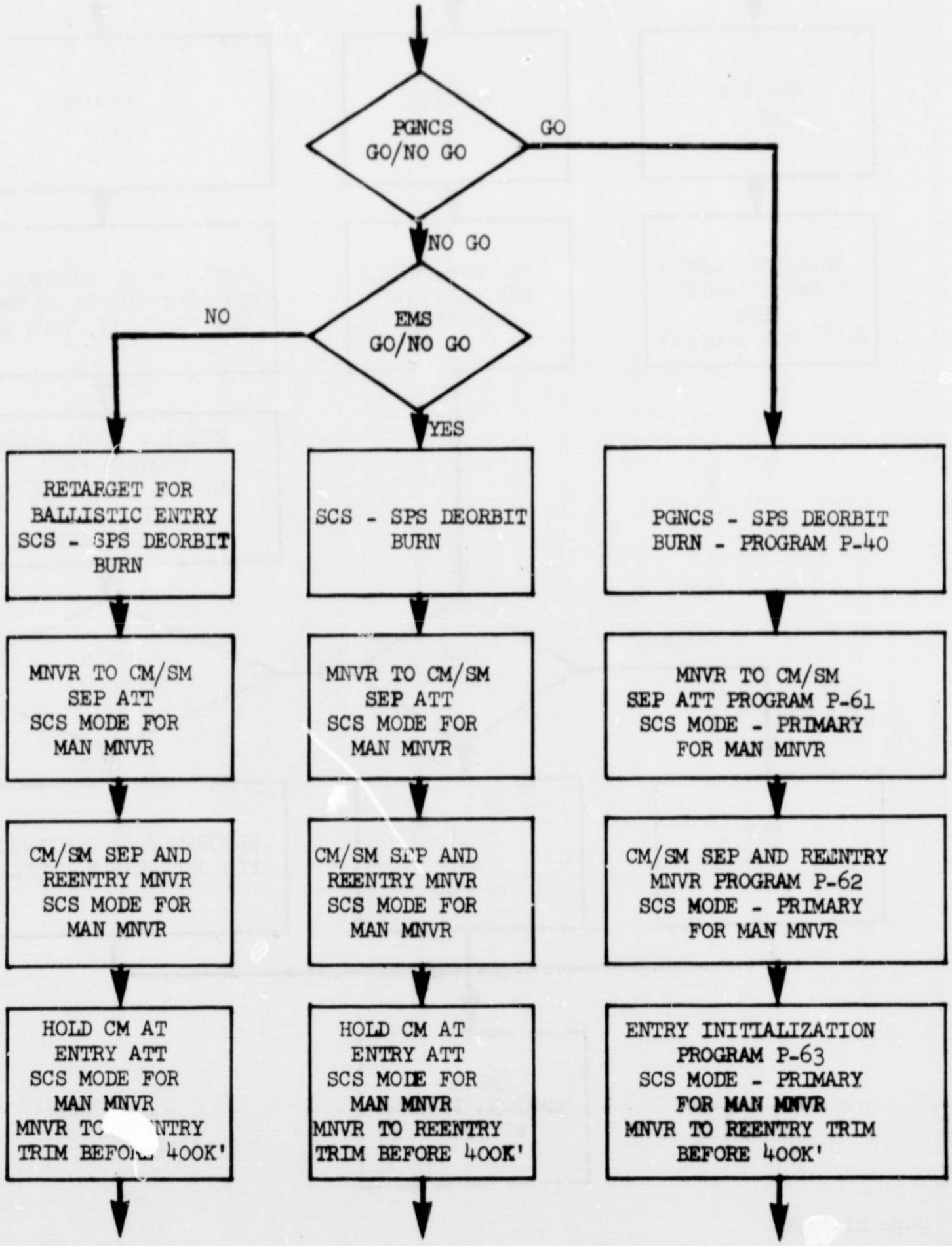
Comments or changes should be directed to Messrs. M. A. Rahman and J. Rippey, Flight Procedures Branch, CF24, utilizing the Procedures Change Form.

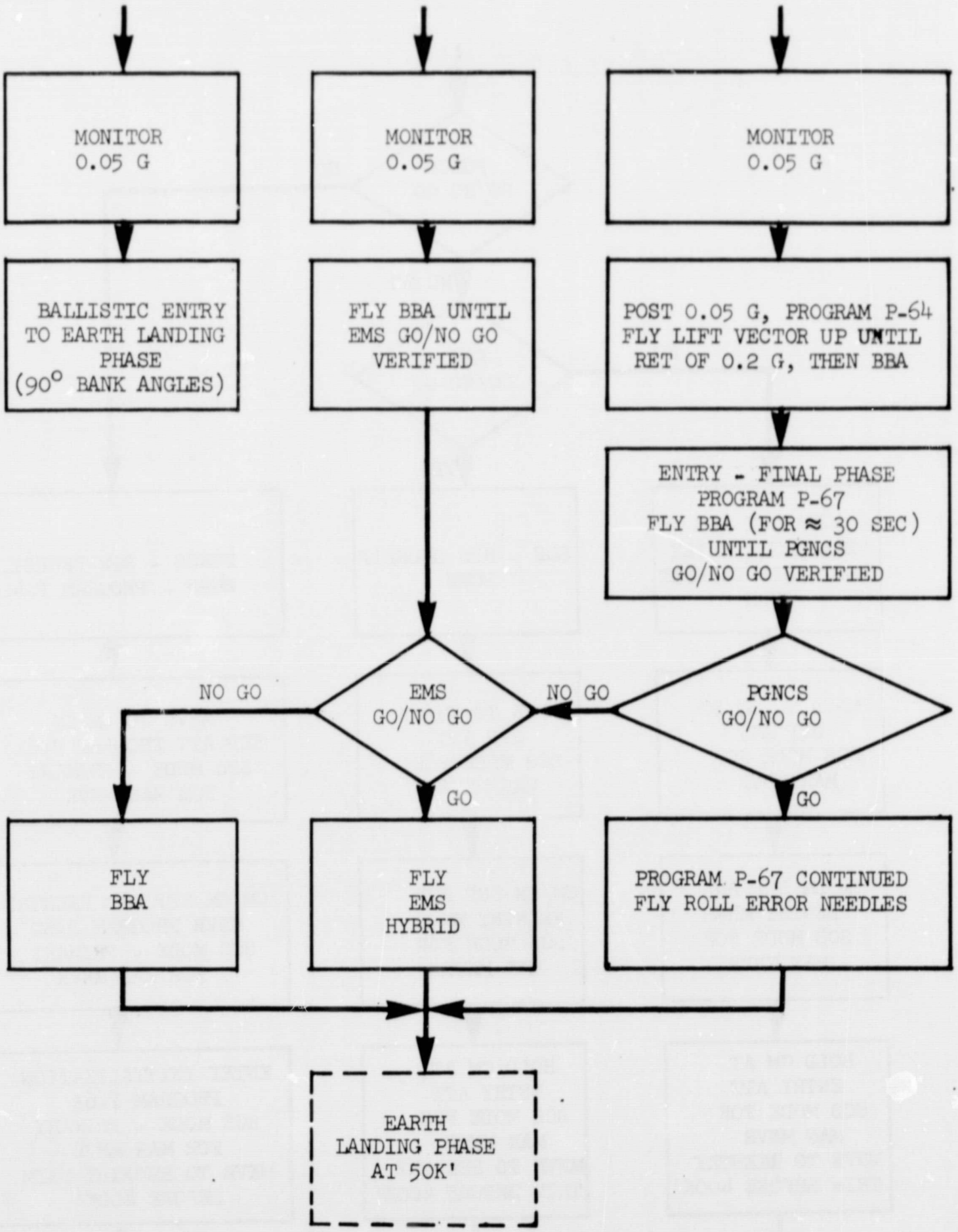
2.0 FLOW DIAGRAM

DEORBIT AND ENTRY PROCEDURES

MISSION 205/101

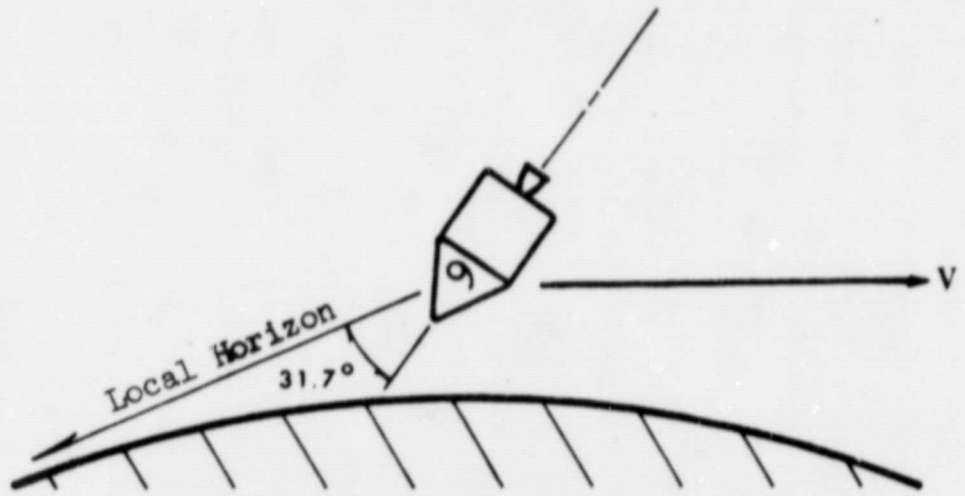



PGNCS GO/NO GO
GO
NO GO
EMS GO/NO GO
NO
YES
RETARGET FOR BALLISTIC ENTRY SCS - SPS DEORBIT BURN
SCS - SPS DEORBIT BURN
PGNCS - SPS DEORBIT BURN - PROGRAM P-40
MNVR TO CM/SM SEP ATT SCS MODE FOR MAN MNVR
MNVR TO CM/SM SEP ATT SCS MODE FOR MAN MNVR
MNVR TO CM/SM SEP ATT PROGRAM P-61 SCS MODE - PRIMARY FOR MAN MNVR
CM/SM SEP AND REENTRY MNVR SCS MODE FOR MAN MNVR
CM/SM SEP AND REENTRY MNVR SCS MODE FOR MAN MNVR
CM/SM SEP AND REENTRY MNVR PROGRAM P-62 SCS MODE - PRIMARY FOR MAN MNVR
HOLD CM AT ENTRY ATT SCS MODE FOR MAN MNVR MNVR TO REENTRY TRIM BEFORE 400K'
HOLD CM AT ENTRY ATT SCS MODE FOR MAN MNVR MNVR TO REENTRY TRIM BEFORE 400K'
ENTRY INITIALIZATION PROGRAM P-63 SCS MODE - PRIMARY FOR MAN MNVR MNVR TO REENTRY TRIM BEFORE 400K'

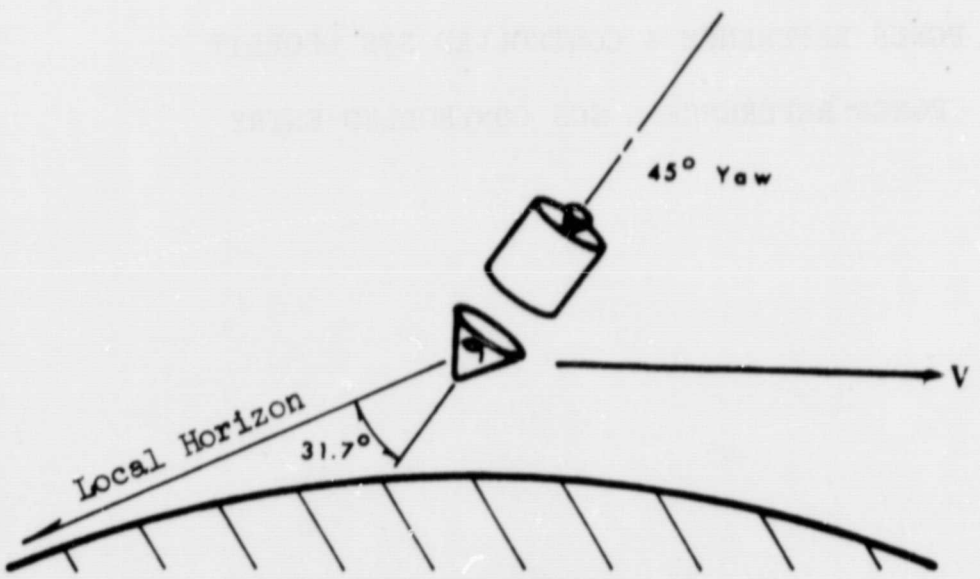

MONITOR
0.05 G
BALLISTIC ENTRY
TO EARTH LANDING
PHASE
(90° BANK ANGLES)
MONITOR
0.05 G
FLY BBA UNTIL
EMS GO/NO GO
VERIFIED
MONITOR
0.05 G
POST 0.05 G, PROGRAM P-64
FLY LIFT VECTOR UP UNTIL
RET OF 0.2 G, THEN BBA
ENTRY - FINAL PHASE
PROGRAM P-67
FLY BBA (FOR ≈ 30 SEC)
UNTIL PGNCS
GO/NO GO VERIFIED
EMS
GO/NO GO
NO GO
PGNCS
GO/NO GO
NO GO
GO
GO
FLY
BBA
FLY
EMS
HYBRID
PROGRAM P-67 CONTINUED
FLY ROLL ERROR NEEDLES
EARTH
LANDING PHASE
AT 50K'

June 21, 1968

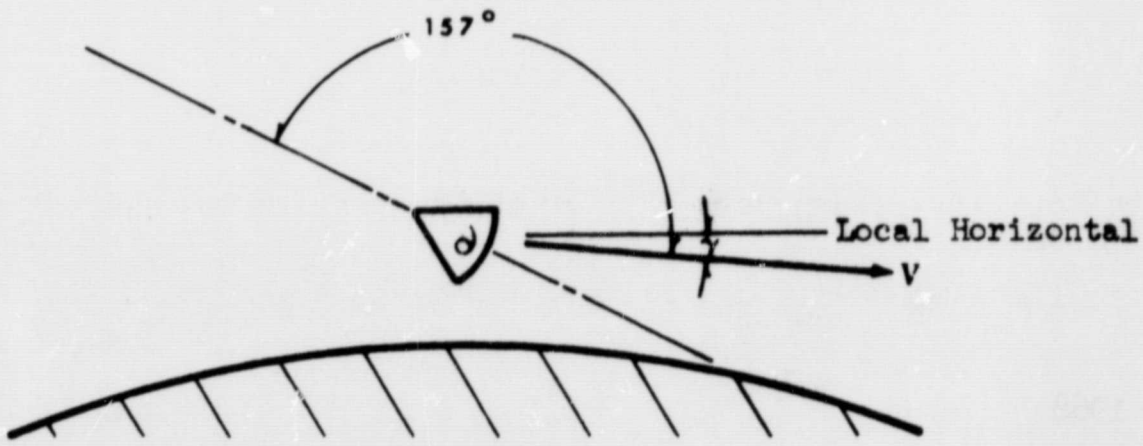
3.0 SPACECRAFT ATTITUDES DURING ENTRY PHASE



SPS Deorbit Attitude



Separation Attitude



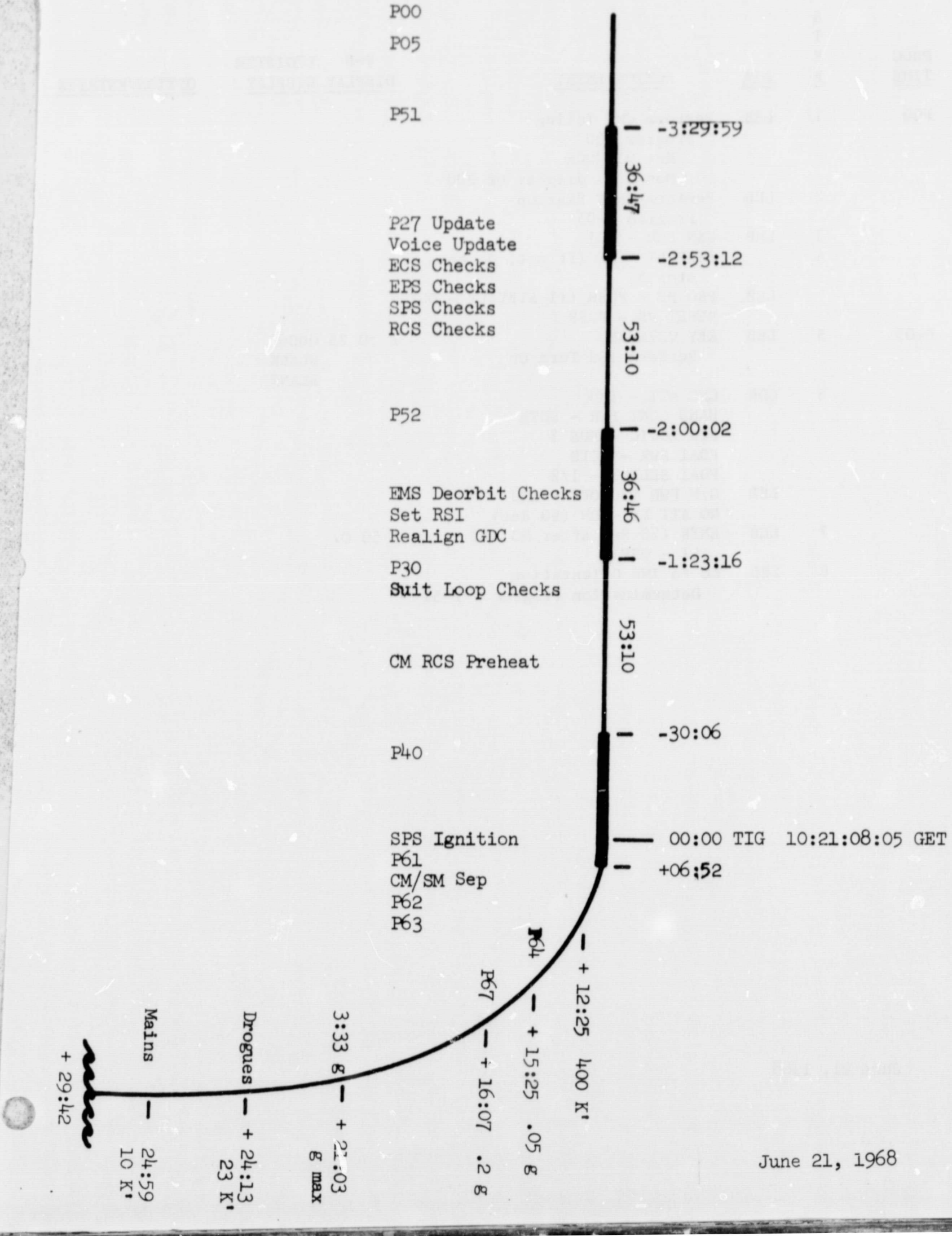
Entry Trim Attitude

June 21, 1968

4.0 PRIMARY DEORBIT & ENTRY PROCEDURES

PGNCS REFERENCE & CONTROLLED SPS DEORBIT

PGNCS REFERENCE & SCS CONTROLLED ENTRY


P00
P05
P51
-3:29:59
36:47
P27 Update
Voice Update
ECS Checks
EPS Checks
SPS Checks
RCS Checks
-2:53:12
53:10
P52
-2:00:02
36:46
EMS Deorbit Checks
Set RSI
Realign GDC
P30
Suit Loop Checks
-1:23:16
53:10
CM RCS Preheat
-30:06
P40
SPS Ignition
P61
CM/SM Sep
P62
P63
00:00 TIG 10:21:08:05 GET
+06:52
P64
+ 12:25 400 K'
P67
+ 15:25 .05 g
+ 16:07 .2 g
3:33 g
+ 24:03
g max
Drogues
+ 24:13
23 K'
Mains
24:59
10 K'
+ 29:42

4.2 COMPUTER PREPARATIONS

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P00	1	LEB	Perform CMC Idling Program P00 Key V37E00E Mon DSKY display of P00			
	2	LEB	Perform GNCS Startup Program P-05			
	3	LMP	G&N PWR - AC1			
	4		STBY LT - ON (If not, go to step 5)			
		LEB	PRO PB - PUSH til STBY LT - OUT RESET PB - PUSH			
P-05	5	LEB	KEY V37E05E Perform ISS Turn On	F 50 25	00060 BLANK BLANK	
	6	CDR	CMC ATT - IMU HAND CONT PWR - BOTH SCS LOGIC - BUS 3 FDAI PWR - BOTH FDAI SELECT - 1/2			
		LEB	G/N PWR IMU/OFF - IMU NO ATT LT - ON (90 Sec)			
	7	LEB	ENTR (20 Sec after NO ATT LT - OFF)	F 50 07		
	8	LEB	Go to IMU Orientation Determination Program - P-51			

4.3 IMU ORIENTATION DETERMINATION PROGRAM: P51

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
-03:40:00	1	CDR	SCS Power Up SCS CHAN (4) - OFF BMAG MODE (3) - RATE 2 SCS ELEC PWR - GDC/ECA BMAG PWR (2) - ON SCS CHAN (4) - ON			
	2	LEB	G/N PWR OPTICS/OFF - OPTICS OPTICS MODE - MAN OPTICS MODE - ZERO (15 SECS)			
P-51	3	LEB	Key V37E51E			
	4		Perform Star Acq	F 50 25	00015 BLANK BLANK	Coarse Align Gmbls PRO-Ret step 4 if NO ATT LT OFF
	5	LEB	ENTER			
	6		Please Mark	F 51 70	STAR CODE BLANK BLANK	Ignore star in R1
	7	LEB	OPTICS MODE - MAN Mark (on star) Perform Terminate Mark Option	F 5C 25	00016 BLANK BLANK	Mark Rej - Step 6
	8	LEB	ENTER Load Star Code	F 01 70	STAR CODE BLANK BLANK	Ignore Star in R1
	9	LEB	Key V21E			
	10	LEB	Load star code			
	11	LEB	PROCEED (Return step 6 for 2nd star) After 2nd star Angular error/diff(<.05°) Angular error/diff(≥.05°) If <.05° Next display 10 sec Change of Program	 06 05 F 06 05 F 50 07	 000.XX DEG 000.XX DEG	 Reject: Key V37E Accept: PROCEED

4.3 IMU ORIENTATION DETERMINATION PROGRAM: P51 (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	12	LEB	Optics Power Down OPTICS MODE - ZERO G/N PWR OPTICS/OFF - OFF			
	13	LMP	G/N PWR AC1/OFF/AC2 - OFF			
	14	ALL	Go to Data Updates and System Checks			

4.4 DATA UPDATES AND SYSTEM CHECKS

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-27	1	LEB	CMC Update Program P-27 UP TLM SW (2) - ACCEPT UPLINK ACTY LT - ON UPLINK ACTY LT - OFF (CMPLT)			P-21 NAV Check Key V37E21E
			UP TLM SW (either) - BLOCK			
	2	LEB	Voice Update			
	3	ALL	ECS Checks Refill surge tank (if necessary)			
	4	ALL	EPS Checks			
	5	ALL	SPS Checks			
	6	ALL	CM RCS and SM RCS Checks			
	7	LEB	Go to IMU Realign Program P-52			

4.5 IMU REALIGN PROGRAM: P-52

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	1	LEB	SCS CHANNELS (4) - ON OPTICS MODE - ZERO (15 SECS)			
	2	LEB	Set Preferred Att Flag: Key V01N01E If D is odd - Flag is already set, otherwise: Key V21E,76E Load - A,B,C,D+1,E INTO R1		R1-ABCDE	
-2:05:00 P-52	3	LEB	Key V37E52E IMU Orientation Option (Preferred is 00001)	F 04 06	00005 00001 BLANK	Load Desired Data
	4	LEB	PROCEED Preferred Option Gmbl Angs (Coarse)R,P,Y	F 06 22	XXX.XX DEG XXX.XX DEG XXX.XX DEG	If MGA >60° Man Mnvr Key V32E
	5	LEB	PROCEED (if MGA <60°) NO ATT LT - ON (<45 Secs) FDAI Drives to Gmbl Angles NO ATT LT - OFF Perform Star Acquisition	F 50 25	00015 BLANK BLANK	Mnvr to Acquire Stars
	6	LEB	ENTER			
	7		Star Code OPTICS MODE - CMC	F 01 70	STAR CODE BLANK BLANK	Key V21E Load Desired Data If OPT MODE - MAN
	8	LEB	PROCEED Desired Shaft Desired Trunnion	06 92	XXX.XX DEG XX.XXX DEG	Go to step 8 Poss Prog Alarm If Trun >38° Mnv to acquire
	9	LEB	OPTICS MODE - MAN			

4.5 IMU REALIGN PROGRAM: P-52 (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	10		Please Mark	F 51 70	STAR CODE BLANK BLANK	
	11	LEB	Mark Term Mark Opt Accept	F 50 25	00016 BLANK BLANK	Mark Reject PB - Push, Step 10
	12	LEB	ENTER Star Code If First Star: OPT MODE - ZERO (15 SECS)	F 01 70	000XX	Load Desired Data
	13	LEB	PROCEED (Return step 7 for 2nd star) After 2nd Star Angular error/diff (<.05°) Angular error/diff (>.05°) If <.05° Next display 10 sec Δ Gyro Torq Ang X,Y,Z	 06 05 F 06 05 F 06 93	 000.XX DEG 000.XX DEG XXX.XX DEG XXX.XX DEG XXX.XX DEG	 Reject: Key V37E Accept: PROCEED Key V32E Return to step 7
	14	LEB	PROCEED Gyros Torqued			
	15	LEB	PERFORM Fine Align Check (Reject Align Check)	F 50 25	00014 BLANK BLANK	Accept Check OPT MODE - ZERO (15 SEC) - ENTER Return to step 7
	16	LEB	PROCEED Change Prog	F 50 07		
	17	LEB	OPTICS MODE - ZERO OR MAN G/N PWR OPTICS - OFF G/N PWR - OFF Go to Prethrust Activities			

4.6 PRETHRUST ACTIVITIES

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
-01:25:00	1	CDR	*Perform EMS Deorbit Test			
			EMS FUNCTION - OFF			
			EMS MODE - STBY (wait 5 sec)			
			EMS FUNCTION - EMS TEST 1			
			Slew scroll to start of test pattern (>5 sec)			
			EMS MODE - AUTO (wait 10 sec)			
			CHECK IND LTS - OFF			
			RANGE COUNTER - 0.0			
			EMS FUNCTION - TEST 2			
			(wait 10 sec)			
			EMS 0.05 G LT - ON (all others out)			
			EMS FUNCTION - TEST 3			
			EMS 0.05 G LT - ON			
			DWN LT - ON (10 sec after 0.05 G Lt)			
			Set range counter to 58 $\pm$ 0.0			
			EMS FUNCTION - TEST 4			
			EMS 0.05 G LT - ON (all others out)			
			G and V trace within test pattern for 10 sec then stops at lower right corner			
			Range counter counts toward zero for 10 sec, then stops at $\approx$0			
			EMS FUNCTION - TEST 5			
			EMS 0.05 G LT - ON			
			RSI UP LT - ON (10 sec after 0.05 G Lt)			
			Range Counter - 0.0			
			Scribe traces vertical line $\approx$9 G to $\approx$0.2 G and stops within test pattern			
			Align scroll to 37K			
			EMS FUNCTION - RNG SET			
			G-V scroll assembly traces vertical line 0.22 G to 0 ($\pm$0.1)			
			Set ΔV Counter to +1586.8			
			EMS FUNCTION (CCW) - ΔV TEST			

4.6 PRETHRUST ACTIVITIES (continued)

ROG IME	STEP P	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
			SPS THRUST LT - ON			
			ΔV Counter decreases (10 secs)			
			SPS THRUST LT - OFF at ≈-0.1 on ΔV Counter			
			ΔV Counter stops at -20.8 ± 20.7			
			EMS MODE - STBY			
	2	CDR	*Set RSI			
			FDAI SELECT - 1/2			
			ATT SET - GDC			
			EMS ROLL - ON			
			GDC ALIGN PB - Push until RSI aligned			
			Adjust yaw thbwl, align RSI			
			EMS ROLL - OFF			
		CDR	*ALIGN GDC TO IMU			
			FDAI SELECT - 1			
			FDAI SOURCE - ATT SET			
			ATT SET - IMU			
			Null error needles W/3 Thbwls			
			FDAI SELECT - 1/2			
			ATT SET - GDC			
			GDC ALIGN - PRESS			
	3	LEB	Go to CSM External ΔV Program P-30			

4.7 CSM EXTERNAL DELTA V PROGRAM: P-30

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-30	1	LEB	Key External ΔV Prog (V37E30E) GETI	F 06 33	00XXX. HRS 000XX. MIN 0XX.XX SEC	Load desired data
	2	LMP	Record values			
	3	LEB	PROCEED LV ΔVG At TIG (X,Y,Z)	F 06 82	XXXX.X FPS XXXX.X FPS XXXX.X FPS	Load desired data
	4	LEB	PROCEED Thrusting Results (HA,HP,ΔVR)	F 06 42	XXXX.X NM XXXX.X NM XXXX.X FPS	
	5	LEB CMP	Record and coordinate W/Gnd *Set ΔV Ctr			Reselect P30 or P27 load new data
	6	LEB	PROCEED TF GETI	F 16 35	00XXX. HRS 000XX. MIN 0XX.XX SEC	
	7	CMP	*Set DET			
	8	LEB	PROCEED Marks TF GETI MGA (at thrust)	F 16 45	XXXXX. XXBXX M/S XXX.XX DEG	
	9	LEB	PROCEED Change program	F 50 07		Select P52
	10	LEB	Go to Prethrusting Entry Checks			

4.8 PRETHRUSTING ENTRY CHECKS

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	1	ALL	*Config for Sep and Entry Suit Loop Verification Mae Wests - Donned			
		CDR	*SUIT RET AIR VLV - PUSH (close)			
		CDR	*Strap in couch			
		LMP	*Strap in couch			
		LEB	*EMERG CAB PRESS VLV - OFF			
-01:00:00	2	CDR	*CB RCS LOGIC (BOTH) - CLOSE *CM RCS LOGIC - ON			
		LEB	*CM RCS HTRS - ON (until min Rdg is 4.9 VDC or 20 min) (Sys Test 5C,D,6A,B,C,D) *URINE DUMP HTR - OFF Set FDAI 2 on orb rate and restow			
	3	LMP	*Test C/W lamps			
-45:00			Dump and rewind tape Rcdr (CRO)			
		ALL	*COMM MODE - LAUNCH/ENTRY			
-40:00	4	LEB	*CM RCS HTRS - OFF *CB PYRO A SEQ A - CLOSE *CB PYRO B SEQ B - CLOSE If PYRO BAT A/B <35 VDC: CB PYRO A/B SEQ A/B - OPEN CB PYRO A/B BAT BUS A/B TO PYRO TIE - CLOSE			
		CMP	*Strap in couch			
		LMP	*CB MN A BAT C - CLOSE *CB MN B BAT C - CLOSE			
-00:35	5	LMP	*Panel 277 CB'S - all closed			
		CDR	*Panel 8 - CB all closed except: PL VENT AND FLOAT BAGS (3) *SECS LOGIC (BOTH) - ON *SECS PYRO (BOTH) - ARM *PRPLNT DUMP - RCS CMD (Verify) *RCS TRNFR - CM *CM RCS PRESS - ON (UP) *CM RCS PRPLNT 1 - ON *Test Thrusters			

4.8 PRETHRUSTING ENTRY CHECKS (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
			*CM RCS FRPLNT 2 - ON *RCS IND SW - CM1, then 2/HE Press - 4000-4450 PSIA Fuel & OX Press - 285-302 PSIA *RCS TRNFR - SM *SECS PYRO (BOTH) - SAFE *SECS LOGIC (BOTH) - OFF			SCS/Select P00
	6	CMP	Go to Program P-40			

4.9 CSM - SPS THRUSTING PROGRAM: P-40

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	1	CMP	Load DAP			
			*Estab ullage select			
		CMP	Key V48E	F 04 46		
			4 Jet with att hold		11102	
					01111	
P-40	2	CMP	Key SPS Thrust Prog (V37E40E)			
			VG Local Vert (X,Y,Z)	F 06 86	XXXX.X FPS	
					XXXX.X FPS	
					XXXX.X FPS	
	3	LMP	Record values			
	4	CMP	PROCEED			
			Preferred Vehicle Att			
			(R,P,Y)	F 06 22	XXX.XX DEG	
					XXX.XX DEG	SCS/Thrust mon
					XXX.XX DEG	Key V37E47E
	5	LMP	Record values			
	6	CMP	PROCEED			
-12:00			(FDAI 2 AT 180 Pitch/Orb Rate)			
	7	CDR	Perform CMC - AUTO	F 50 25 00203		Select DAP Control
			*MAN MNVR			BMAG MODE - RATE 2
		CMP	PROCEED			ENTER - F 06 22
			Att Trim Man Enable	F 50 19		
-05:30		CDR	*DIRECT RCS - OFF			
			BMAG MODE (3) - RATE 2			
			SC CONT - CMC			
			CMC MODE - AUTO			
			SCS TVC (Both) - RATE CMD			SCS/TVC - AUTO
			*TVC GMBL DRIVE P AND Y - AUTO			
			*TVC SERVO PWR 1 & 2 - AC1/AC2			
			*HAND CONT PWR - 1			
			*RHC #2 - Unlocked			
			*MN BUS TIE (Both) - ON			
			*GMBL MOTOR PITCH 1 and YAW 1			SCS/Confirm trim
			START - ON			control
			*THC - CW			
			*Verify no MTVC			

4.9 CSM - SPS THRUSTING PROGRAM: P-40 (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
			*GMBL MTR PITCH 2 and YAW 2 - START - ON Confirm and set GPI trim *Verify MTVC *THC - Neutral			
	8	CMP	PROCEED Possible (Perform CMC - AUTO)	F 50 25	00203	Select DAP control
	9	CMP	PROCEED			
	10	CMP	Perform Enable GMBLS Option	F 50 25	00204	
	11	CMP CDR	*ENTER *DIRECT RCS - ON *HAND CONT PWR - Both MAN ATT (3) - RATE CMD BMAG MODE (3) - ATT 1/RATE 2 If TF GETI <45 sec FL 05 09 PROCEED or V34E Terminate			SCS/Set GPI trim SCS/Null errors then MIN DEADBAND
	12	CMP	Monitor (TF GETI, VG,ΔVM)	06 40	XXBXX M/S XXXX.X FPS XXXX.X FPS	
-02:00		CDR	*FDAI SCALE - 5/5 *ΔV THRUST A AND B - NORMAL *THC - ARMED *RHC (BOTH) - ARMED			SCS/LIMIT CYCL - OFF
-00:30		CDR	*EMS FUNCTION - ΔV *EMS MODE - AUTO *CHECK PIPA BIAS - <0.2 FPS in 5 sec (TBD)			
-00:15			*4 Jet ullage			Backup - DIRECT ULLAGE PB

4.9 CSM - SPS THRUSTING PROGRAM: P-40 (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
			*Cont att with RHC			
			*Monitor ΔVM counting up			
-00:05			Engine on enable	F 50 99	XXBXX M/S	No go/V34E
			(TFE,VG,ΔVM)		XXXX.X FPS	
					XXXX.X FPS	
	13	CMP	ENTER			SCS/THRUST ON PB -
-00:00			Ignition			PUSH
		CDR	Monitor (TFC decreasing)	06 40	XXBXX M/S	
			(VG decreasing)		XXXX.X FPS	
			(ΔVM increasing)		XXXX.X FPS	
			*ΔV THRUST A AND B - OFF			
			SC CONT - SCS			
			*Verify all thrust off cues			
			*GIMBAL MTRS (4) - OFF			
			*TVC SERVO PWR 1 and 2 - OFF			
			*RHC #1 - Locked			
	14	CMP	PROCEED			
			Monitor (VGX,Y,Z)	F 16 85	XXXX.X FPS	
					XXXX.X FPS	
					XXXX.X FPS	
			*EMS MODE - STBY			
			*Record ΔV counter/components			
	15	CMP	PROCEED	F 06 44	XXXX.X NM	
			(HA,HP,TFF)		XXXX.X NM	
					XXBXX M/S	
						IF Hp >50 F 06 32
						Time from Hp
	16	CMP	PROCEED			hr/min/sec PROCEED
			Hp <50 NM	F 50 07		
	17	CMP	Go to Program P-61			

4.10 MANEUVER TO CM/SM SEPARATION ATTITUDE: P-61

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-61	1	CMP	Key V37E61E			
	2		Preseparation Functions *PRIM GLY TO RAD HANDLE - PULL *PLSS VLV - ON *02 SM SUPPLY VLV - OFF *CAB PRESS REL VLV (2) - BOOST/ENTRY Monitor Surge TK Press *Yaw 45° out of plane for sep *VHF AM (both) - SIMPLEX *VHF ANT - RECY *S BAND ANT - TBD *SM RCS PRIM PRPLNT A (BCD) - ON (UP), TB A (BCD) - Gray *SECS LOGIC (both) - ON *SECS PYRO (both) - ARM *CM/SM SEP (both) - ON (up) *C/W MODE - CM *RCS TRANS - CM (verify) *CM RCS LOGIC - OFF *Mnvr to entry att R____,P____,Y 0° *B/D ROLL,PITCH AND YAW - CHAN A *Open all SCS chan CBs except: CB B/D ROLL 1 MN A - Closed CB PITCH MN A - Closed CB YAW MN A - Closed			Delay Mnvr >1 min after step 1 for average g calc.
	3		Program 61 displays Gmax,Vpred,Gamma EI	F 06 60	XXX.XX G XXXXX. FPS XXX.XX DEG	
	4	LMP	Record Data (optional)			
	5	CMP	PROCEED RTGO,VIO,TFE	F 06 63	XXXX.X NM XXXXX. FPS XXBXX M/S	
	6	LMP	Record			
	7	CMP	PROCEED Perform CMC - AUTO *MAN MNVR	F 50 25	00203 BLANK BLANK	Select DAP control BMAG MODE - RATE 2 ENTER - F 06 22
	8	CMP	PROCEED Att Trim Enable	F 50 19		
	9	CMP	PROCEED P62 Displayed			Key V37E62E

4.11 SEPARATION AND PREENTRY MANEUVER: P-62

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-62	1	CMP	Monitor DSKY - Display of P-62 Perform Sep Checklist	F 50 25	00041	Poss prog alarms 1427 & 1426 - RESET
	2	CMP	Key V40N20E (to reset IMU bit) (wait 6 sec)			
	3	CMP	KEY RLSE	F 50 25		
	4	CMP	ENTER Impact LAT (+north) Impact LONG (+east) Heads Up/Down	F 06 61	XXX.XX DEG XXX.XX DEG 00001 +/-	
	5	CMP	PROCEED			Load desired data
	6	LMP	Record postburn data from GND Roll gmbl angle at 400K ft BBA RET RB (retro elapsed time of reverse bank angle) RET 0.2 G Down range error RTGO (0.05 G) VIO (0.05 G) RET 0.05 G RET BBO (retro elapsed time of blackout) RET EBO (retro elapsed time of end blackout) RET DROG			POSSIBLE F 06 22 FNL GML < (R,P,Y)
	7	CDR	*EMS FCN - CW TO RNG SET *Set Rng Counter for RTGO *EMS FCN - VO SET *Align scroll VO to VIO *EMS FCN - ENTRY *EMS MODE - AUTO *ATT DEADBAND - MAX *RATE - HIGH *Set DET - f(TIG)			
	8	CMP	Monitor DSKY - Display of P-63			Called when S/C +X within 45° of velocity vector

4.12 ENTRY INITIALIZATION PROGRAM: P-63

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-63	1	CDR	*BMAG MODE (3) - RATE 2			
			*MAN ATT ROLL - ACCEL CMD *MAN ATT P AND Y - RATE CMD			
	2	CMP	Monitor DSKY - Display of P-63 G,VI,R TO TARG (+overshoot)	06 64	XXX.XX G XXXXX. FPS XXXX.X NM	
	3	CMP	*Note R3 agrees with EMS range counter at 0.05 G EMS RTGO starts down at 0.05 G			
		CDR	*0.05 G sw - ON (up) *EMS ROLL - ON (up)			
	4	CMP	Monitor DSKY - Display of P-64			P-64 auto at 0.05G

4.13 POST 0.05 G PROGRAM: P-64

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-64	1	CMP	Monitor DSKY - Display of P-64 BETA, VI, H DOT	06 68	XXX.XX DEG XXXXX. FPS XXXXX. FPS	
	2		*Fly Lift vector up until predicted 0.2 G time, then BBA			
	3	CMP	Monitor DSKY - Display of P-67			P-67 auto at 0.2G

4.14 ENTRY FINAL PHASE PROGRAM: P-67

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-67	1	CMP	Monitor DSKY - Display of P-67			
			BETA	06 66	XXX.XX DEG	
			CROSS RANGE ERR		XXXX.X NM	
			DOWN RANGE ERR		XXXX.X NM	
			Compare R3 with Gnd and/or chart data			
	2	CDR	*Maintain BBA until PGNCS verified			SCS/If PGNCS no go fly EMS Hybrid Page _____
	3	CDR	Fly roll error needles			
			*Mon RSI and FDAI roll			
			*Establish comm w/Gnd as soon as possible			
	4		When V REL = 1000 FT/SEC (65K')			
			RTGO	F 16 67	XXXX.X NM	
			LAT (+NORTH)		XXX.XX DEG	
			LONG (+EAST)		XXX.XX DEG	
			IF R1 =-, L up, if R1 =+, L dn.			
	5	CMP	*Monitor Altimeter			
	6	ALL	*Go to Earth Landing Phase at 50K'			

4.15 EARTH LANDING PHASE

PROG TIME	STEP P	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	1	CDR	Monitor altimeter			
30K'			ELS LOGIC - ON			
			ELS - AUTO			
24K'			Apex cover jett			APEX COVER PB
			Drogues deployed			DROGUE PB
23.5K'			Cabin pressure increasing			CABIN PRESS REL - DUMP if not incr by 17K'
10K			Mains deploy			MAIN DEPLOY PB
	2	CDR	DIRECT O2 VLV - OPEN (ccw)			
			CABIN PRESS REL VLV (2) - CLOSE			
			CM RCS LOGIC - ON			
			CM PRPLNT DUMP - ON (burn audible)			Dump after disreef (Mains + 10sec)
3500'			Burn not complete, use both RHC's (12 eng)			
	3	LMP	CB FLT & PL BAT BUS A, B, & BAT C (3) - Close			
			CB FLT & PL MN A & B (2) - Open			
			FLOOD POST LDG			
		ALL	Comm set up for ldg			
		CDR	Voice report			
			CM PRPLNT PURGE - ON (up) (to zero He press)			
			CAB PRESS REL VLVs (2) - BOOST/ENTRY			CM RCS HE DUMP PB - Push RHC (2) - 30 sec no pitch
1500'		CDR	Purge not complete: PURGE - OFF			
			CAB PRESS REL VLVs (both) BOOST/ENTRY			
			CM RCS PURGE, DUMP & LOGIC - OFF			
			CM RCS PRPLNT (both) - OFF			
			CAB PRESS REL VLV (both) - CLOSE			
			Landing			
			Post Landing Check			

5.0 BACKUP DEORBIT PROCEDURES

5.1 SCS Reference & Controlled SPS Deorbit

This procedure is incorporated in the primary procedure so that an immediate switchover can be accomplished. In the event of a PGNCS failure only the asterisked steps and the SCS labeled comments in the option/entries column need to be accomplished for an SCS deorbit.

5.2 PGNCS Reference & Controlled CSM RCS Deorbit

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	1	CDR	IMU-ON (Req) CMC-ON (Req) SCS-ON (Req) CMC ATT-IMU 0.05G sw - OFF SCS LOGIC BUS(3)-ON			
	2	CMP	Call DAP Data Load Rou (R03) Key (V48E) (Load R1 11112 and R2 01111)	F 04 46	XXXXX XXXXX BLANK	Load desired DAP
	3	CMP	PROCEED IX (Slug ft sq/100) (IY + IZ)/2 (Slug ft sq/100) WT If Hybrid burn WT=00000	F 06 47	XXXXX. XXXXX. XXXXX. lb	Verify/ Load desired DAP
	4	CMP	PROCEED P Trim Y Trim TLX (Ft-lb/100)	F 06 48	XXX.XX DEG XXX.XX DEG XXXXX.	Verify/ Load desired DAP
	5	CMP	PROCEED			
-00:10:00	6	CDR	Prim GLY to Rad - Pull to bypass 02 PLSS VLV - ON 02 SM supply vlv - OFF Cab press rel vlv (2) - BOOST/ENTRY 02 TK1 - Surge TK			
		CMP	SM RCS PRIM PRPLNT (4) - ON SM RCS PRIM PRPLNT TB (4) - GRAY			
		CDR	SECS logic (both) - ON (up) SECS PYRO arm (2) - ON (up)			
P-41	7	CMP	Key RCS Thrusting Prog (V37E41E) Specify trans axis 1 = +X	F 04 06	00004 00001	Accept displayed option code.

5.2 PGNCS Reference & Controlled CSM RCS Deorbit (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	8	CMP	PROCEED VGX, VGY, and VGZ (Cont-present CSM axes)	F 06 85	XXXX.X FPS XXXX.X FPS XXXX.X FPS	
	9	IMP	Record values Estimate thrust direction and att change for translation per CSM axis			
	10	CMP	PROCEED Preferred attitude (R,P,Y) FNL GMBL Angles - Heads up	F 06 22	XXX.XX DEG XXX.XX DEG XXX.XX DEG	If R3 > 20° reselect P-52 then P-41
	11	LMP	Record values			
	12	CMP	PROCEED VGX, VGY, and VGZ (LCL vert)	F 06 86	XXXX.X FPS XXXX.X FPS XXXX.X FPS	
	13	LMP	Record values For hybrid burn verify no rotation of LCL vert delta Vs			
	14	CMP	PROCEED CMC - AUTO Request	F 50 25	00203	
			Establish Total Att Disp			
		CDR	FDAI Scale as desired FDAI PWR - BOTH FDAI SEL - 1/2 FDAI 1 SW - INRTL (desired)			
		CMP	Reject auto manvr - Select Attitude Control Mode compatible with the magnitude of the maneuver - E.G. rate command, accel command or minimum impulse and the desired rates.			

5.2 PGNCS Reference & Controlled CSM RCS Deorbit (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
			Use recorded pad data for R= P= Y=			
			Perform maneuver with RHC.			
	15	CMP	PROCEED			
			Att Trim Enable (R,P, and Y) Auto Att Trim Request	F 50 19	XXX.XX DEG XXX.XX DEG XXX.XX DEG	
		CDR	Reject Auto Trim - Select attitude control mode compatible with the magnitude of the maneuver - E.G. rate command, accel command or minimum impulse and the desired rates. Perform Maneuver with RHC. SC CONT - CMC CMC MODE - AUTO or HOLD			Accept Auto Trim - BMAG mode(3) - Rate SC CONT-CMS CMC MODE-AUTO ENTER V06 N22 Monitor Auto Trim
	16	CDR	Establish Att Hold BMAG MODE(3) - Att 1 Rate 2			
-00:05:00	17	CMP	PROCEED VGX, VGY, and VGZ (CSM Axes before att manvr)	06 85	XXXX.X FPS XXXX.X FPS XXXX.X FPS	If TTI < 30 sec then GETI is slipped to 30 sec after step 16
	18	CDR	Ignition Preparation EMS FUNC - DELTA V SET Set delta V ind to SM portion of burn EMS FUNC - DELTA V			
-00:00:30		CDR	THC - ARMED RHC (both) - ARMED LIMIT CYCLE - OFF			
		CMP	FLT RCRD - RECORD			
		CDR	EMS MODE - AUTO			

5.2 PGNCS Reference & Controlled CSM RCS Deorbit (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
		LMP	TAPE RCDR-RCD TAPE RCDR-FWD MIN BUS TIE (2) - ON			
-00:00:15			VECTOR COMPONENTS VGX, VGY, and VGZ (Cont-CSM axes) PIPA bias < .2 fps in 5 sec	F 16 85	XXXX.X FPS XXXX.X FPS XXXX.X FPS	
00:00:00	19		SM/Burn			
		CDR	EVENT TIMER - RESET - START Burn EMS delta V to zero If SM burn only go to step 25			
	20		CM/SM Separation			
		CDR	SC CONT- SCS			
		CMP	CM/SM SEP (both) - ON (up) C/W CSM - CM RCS TRANSFER - CM (verify)			
	21		Maneuver to CM/burn attitude Use recorded pad data for R= P= Y=			
		CDR	Select attitude control mode compatible with the magnitude of the maneuver - E.G. rate command, accel command or minimum impulse and the desired rates. Perform maneuver with RHC by nulling err needles.			
	22		Establish att disp for CM/burn			
		CMP	Key (V25 N 22E) Key in desired IMU ang for CM/RCS burn Use recorded pad data for R= P= Y= Key Rel PB-PUSH	F 06 22	XXX.XX DEG XXX.XX DEG XXX.XX DEG	

5.2 PGNCS Reference & Controlled CSM RCS Deorbit (continued)

ROG IME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
			Vector components VGX, VGY, and VGZ	F 16 85	XXXX.X FPS XXXX.X FPS XXXX.X FPS	
	23		Establish att control			
		CDR	ROLL, YAW - RATE CMD PITCH - ACC CMD RATE - LOW ATT DEADBAND - MIN LIMIT CYCLE - OFF FDAI SCALE - 5/5 (desired)			
	24		Perform CM/RCS burn			
		CMP	RHC - 1, Initiate continuous neg pitch			
		CDR	RHC - 2, Pulse plus pitch to maintain attitude (FDAI 1) in 3 axis Burn VGZ to zero			
	25		R30 - Orbital Parameter display			
		CMP	Key (V82E)			
			HA	F 06 44	XXXX.X NM	
			HP		XXXX.X NM	
			TFF		XXBXX. M/S	
			Check HP			
			Key (V34E)			
			Vector components VGX, VGY, and VGZ	F 16 85	XXXX.X FPS XXXX.X FPS XXXX.X FPS	
			If Hp > pad data go to step 19 (SM burn only) or go to step 24 (hybrid)			
	26	CDR	EMS MODE - STBY THC - NEUTRAL - LOCKED			
		CMP	FTL RCDR - OFF (center)			

5.2 PGNCS Reference & Controlled CSM RCS Deorbit (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	27		Maneuver to SM/burn attitude use recorded pad data for R= P= Y=			
		CDR	Select attitude control mode compatible with the magnitude of the maneuver - E.G. rate command, accel command or minimum impulse and the desired rates. Perform maneuver with RHC.			
	28	LMP	Read VGs residual to ground			
	29	CMP	PROCEED R30 - Orbital Parameter Disp HA HP TFF	F 06 44	XXXX.X NM XXXX.X NM XXBXX. M/S	If HP >50 NM F 06 32 PROCEED
	30	CMP	PROCEED	F 50 07		
			If SM burn only go to step 31			
		LMP	VHF AM (BOTH) - RECY			
		CDR	CM RCS LOGIC - OFF			
		LMP	S BD ANT (2) - TBD			
	31	CMP	Go to Entry Phase, Section 4.10			

5.3 SCS Reference & Controlled CSM RCS Deorbit

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	1	CDR	IMU - ON (Req) CMC - ON (Req) SCS - ON (Req) CMC ATT - IMU 0.05G sw - OFF SCS LOGIC BUS (3) - ON			
P-00	2	CMP	Key DSKY P00 (V37E00E)			
	3		Establish total attitude displays			
		CDR	FDAI PWR - 1, 2, or both FDAI Scale as desired FDAI 1 sw-inrtl (desired) FDAI SEL - 1 or 2 FDAI SOURCE - GDC			
			Att set Tmbwhl - adjust to CM thrusting att gimbal angles. Use recorded pad data for R= P= Y=			
-00:10:00	4	CDR	PRIM GLY TO RAD - PULL TO BYPASS 02 PLSS vlv - ON 02 SM supply vlv - OFF CAB PRESS rel vlv (2) - BOOST/ENTRY 02 TK1 - SURGE TK			
		CMP	SM RCS PRIM PRPLNT (4) - ON SM RCS PRIM PRPLNT TB (4) - GRAY			
		CDR	SECS LOGIC (both) - ON (up) SECS PYRO ARM (2) - ON (up)			
	5		SCS attitude maneuver to thrusting attitude Use recorded pad data for R= P= Y=			
		CDR	Select attitude control mode compatible with the magnitude of the maneuver - E.G. rate command, accel command or minimum impulse and the desired rates.			

5.3 SCS Reference & Controlled CSM RCS Deorbit (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
			Perform maneuver with RHC			
	6		Establish total attitude			
		CDR	BMAG MODE (3) - Attl Rate2			
			MAN ATT (3) - RATE CMD			
			LIMIT CYCLE - ON			
			RATE - LOW			
			ATT DBD-MAX			
-00:05:00	7		Ignition preparation			
		CDR	EMS FUNC - DELTA V SET			
			Set Delat V ind to SM portion of burn			
			EMS FUNC - DELTA V			
			If CMC - OFF and ISS-OFF go to step 9.			
P-47	8	CMP	Key Thrust Monitor Prog P-47			
-00:02:00			(V37E47E)			
			After 1 Min			
			Delta V components (X,Y,Z)	F 16 83		XXXX.X FPS
			Check for PIPA bias			XXXX.X FPS
			til thrust applied			XXXX.X FPS
-00:00:30	9	CDR	RHC (both) - ARMED			
			THC - ARMED			
			ATT DBD - MIN			
			LIM CYCLE - OFF			
		CMP	FLT RCDR - RECORD			
		LMP	TAPE RCDR-RCD			
			TAPE RCDR-FWD			
		CDR	EMS MODE - AUTO			
		LMP	MN BUS TIE(2) - ON			
00:00:00	10		SM/burn			
		CDR	EVENT TIMER - RESET - START			
			Burn EMS delta V to zero			
			If SM burn only go to step 15			

5.3 SCS Reference & Controlled CSM RCS Deorbit (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	11		CM/SM Separation			
		CMP	CM/SM SEP 9BOTH) - ON (up) CW/ CSM - CM RCS TRANFR - CM (verify) FDAI SOURCE - ATT SET ATT SET - GDC			
	12		Maneuver to CM/burn att Use recorded pad data for R= P= Y=			
		CDR	Select attitude control mode compatible with the magnitude of the maneuver - E.B. rate command, accel command or minimum impulse and the desired rates. Perform maneuver with RHC by nulling err needles.			
	13		Establish att control			
		CDR	ROLL, YAW - RATE CMD PITCH - ACC CMD ATT DEADBAND - MIN LIMIT CYCLE - OFF FDAI SCALE - 5/5 (desired)			
	14		Perform CM/RCS burn			
		CMP	RHC - 1, initiate continuous neg pitch			
		CDR	RHC - 2, Pulse plus pitch to maintain attitude (FDAI 1) in 3 axis Burn delta V to pad data			
	15		If CMC-OFF and ISS-OFF go to step 16			
		CMP	Key (V82E) R30 - Orbital Parameter display HA HP TFF Check HP	F 06 44	XXXX.X NM XXXX.X NM XXBXX. M/S	

6.0 BACKUP ENTRY PROCEDURES

6.1 ENTRY FINAL PHASE PROGRAM: P-67

(ENTRY DAP CONTROL MODE)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-67	1	CMP	Monitor DSKY - Display of P-67			
			BETA	06 66	XXX.XX DEG	
			CROSS RANGE ERR		XXXX.X NM	
			DOWN RANGE ERR		XXXX.X NM	
			Compare R3 with Gnd and/or chart data			
	2	CDR	Maintain BBA until PGNCS Verified			SCS/If PGNCS no go fly EMS Hybrid
	3	CDR	PGNCS/Go - Fly PGNCS			
			MAN ATT ROLL - RATE CMD			
			SC CONT - CMC			
			Mon RSI and FDAI roll			
			Establish Comm W/Gnd as soon as possible			
	4		When V REL = 1000 FT/SEC (65K')			
			RTGO	F 16 67	XXXX.X NM	
			LAT (+NORTH)		XXX.XX DEG	
			LONG (+EAST)		XXX.XX DEG	
			IF R =- , L UP. IF R =+, L DN.			
	5	CMP	Monitor Altimeter			
	6	ALL	Go to Earth Landing Phase at 50K'			

6.2 ENTRY FINAL PHASE PROGRAM: P-67

(EMS HYBRID FLIGHT TECHNIQUE)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-67	1	CMP	Monitor DSKY - Display of P-67			
			BETA	06 66	XXX.XX DEG	
			CROSS RANGE ERR		XXXX.X NM	
			DOWN RANGE ERR		XXXX.X NM	
			Compare R with Gnd and/or chart data			
			Roll to -BBA at RET 0.2G			
	2	CDR	Maintain -BBA until PGNCS verified			
	3	CDR	PGNCS/No Go - Fly EMS Hybrid Technique:			
			A. At time to reverse bank (TRB), roll from -BBA to +BBA.			
			B. Pilot adjusts -BBA and + BBA so range potential lines and range-to-go counter are in agreement. The value of TRB may also be modified by the pilot to compensate for adjustments in BBA, so that cross range error averages out.			
			C. An additional check is available at the 4,000 FPS point. The range-to-go counter should read about 27 miles at this checkpoint, in order for the counter to read 0 at drogue deploy.			
			At 4,000 FPS on the scroll, if the range-to-go counter reads more than 27 (TBD) miles to go, the pilot holds full lift up until drogues deploy, otherwise full lift down.			

6.2 ENTRY FINAL PHASE PROGRAM: P-67 (continued)

(EMS HYBRID FLIGHT RECHNIQUE) (continued)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
	4	CDR	Mon RSI and FDAI roll Establish Comm W/Gnd as soon as possible			
	5	CMP	Monitor Altimeter			
	6	ALL	Go to Earth Landing Phase at 50K'			

6.3 ENTRY FINAL PHASE PROGRAM: P-67

(BBA FLIGHT TECHNIQUES)

PROG TIME	STEP	STA	ACTION/ENTRY	V-N DISPLAY	REGISTER DISPLAY	OPTION/ENTRIES
P-67	1	CMP	Monitor DSKY - Display of P-67			
			BETA	06 66	XXX.XX DEG	
			CROSS RANGE ERR		XXXX.X NM	
			DOWN RANGE ERR		XXXX.X NM	
			Compare R3 with Gnd and/or chart data			
	2	CDR	Maintain -BBA until time to reverse bank angle (TRB)			
	3	CDR	Fly +BBA till drogue deploy			
			Maintain BEF			
			Mon RSI and FDAI roll			
			Establish Comm W/Gnd as soon as possible			
	4		When V REL = 1000 FT/SEC (65K')			
			RTGO	F 16 67	XXXX.X NM	
			LAT (+NORTH)		XXX.XX DEG	
			LONG (+EAST)		XXX.XX DEG	
			If R1=-, L UP, If R1=+, L DN.			
	5	CMP	Monitor Altimeter			
	6	ALL	Go to Earth Landing Phase at 50K'			

Appendix A. Instrumentation Descriptions

A. FLIGHT DIRECTOR ATTITUDE INDICATOR

The FDAI provides a display for monitoring spacecraft total attitude, attitude rate, and attitude error with respect to a selected inertial frame. The spacecraft attitude in the roll, pitch, and yaw planes is observed using this display while maintaining attitude or performing maneuvers for alignment, thrusting, or separation in reentry procedures.

The FDAI associated switches determine the source of display data, the FDAI selected, and the full scale deflections of the attitude rate and error needles. Other switches also modify the data displayed and will be pointed out in the individual switch descriptions. The switch positions are illustrated in

1. FDAI SCALE SWITCH

The FDAI SCALE switch is a three position switch which controls the attitude error and rate display full scale deflection values. Scale selection is independent of other panel switch positions and is common to both FDAI's. The switch position and associated scales are as follows:

Position	Error Scale	Rate Scale
UP	5° R, P, & Y	1°/sec R, P, & Y
CENTER	5° R, P, & Y	5°/sec R, P, & Y
DOWN	50° R, 15° P & Y	50° R, 10° P & Y

2. FDAI SELECT SWITCH

The FDAI SELECT switch is a three position switch that determines which FDAI(s) will display the selected outputs. The selection is described below:

Position	Description
1/2	This position permits both FDAI's to receive and display active inputs. The No. 1 FDAI will display G and N inputs while FDAI No. 2 will display SCS inputs.
2	Only FDAI No. 2 will accept total attitude and attitude error inputs. These inputs are controlled by the FDAI SOURCE switch and the ATT SET switch.
1	Only FDAI No. 1 will accept total attitude and attitude error inputs. These inputs are controlled by the FDAI SOURCE switch and the ATT SET switch.

3. FDAI SOURCE SWITCH

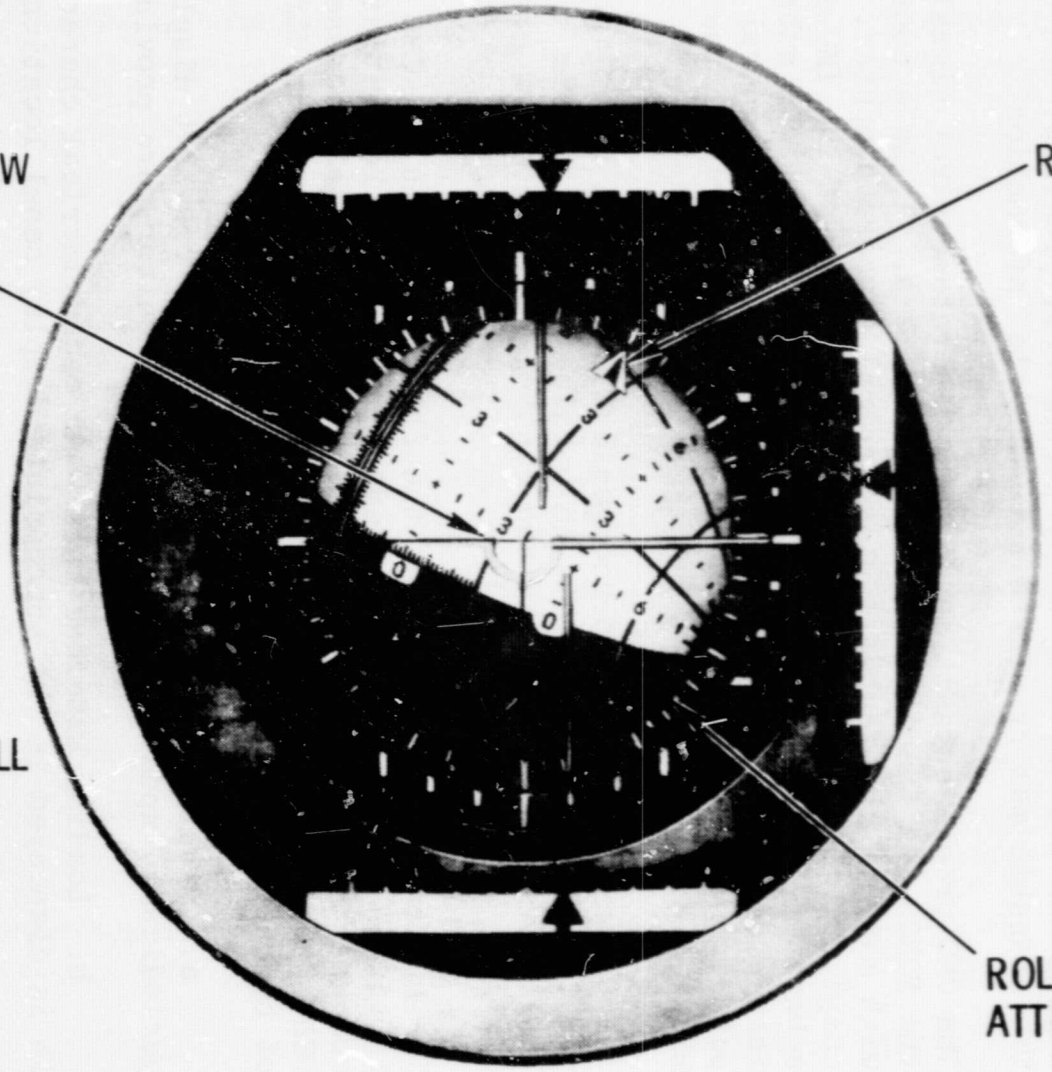
The FDAI SOURCE switch selects the display's signal source. It is a three position switch that has no active function if the FDAI SELECT switch is in the UP position. Otherwise, the information may be selected as follows:

Position	Description
UP	The CMC position enables inputs from the G and N for total attitude and attitude error. The error display will reflect differences generated from the CMC program selection.
CENTER	The ATT SET position selects SCS body reference attitude errors if ATT SET switch is in the GDC position. This displayed error can be used for manual maneuvering to a new attitude or verification of GDC alignment. The total attitude will be displayed with respect to the GDC alignment. If ATT SET switch is in the IMU position, the attitude error will be the difference between the IMU and attitude set thumbwheel resolvers. The total attitude will be from the IMU.
DOWN	The GDC position selects inputs from the SCS for total attitude and attitude errors to the FDAI selected. The errors are displayed from BMAG No. 1 if it is not caged for rate information.

Figure A-1

FLIGHT DIRECTOR ATTITUDE INDICATOR

ROLL
+ANGULAR VELOCITY-
+ATTITUDE ERROR-



EULER ATTITUDE ON BALL
PITCH - θ = 014°
YAW - ψ = 034°
ROLL - ϕ = 330°

NOTE:
ALL POLARITIES INDICATE VEHICLE DYNAMICS

PITCH

-		-
ATTITUDE ERROR		ANGULAR VELOCITY
+		+

YAW
+ATTITUDE ERROR-
+ANGULAR VELOCITY-

B. COMPUTER SUBSYSTEM

The Computer Subsystem (CSS) consists of the Command Module Computer (CMC), and two display and keyboard panels (DSKYs). The CMC and one DSKY are located in the lower equipment bay. The other DSKY is located on the main display console. All CMC controls and displays are located on the DSKYs.

The CMC is a core memory, digital computer with two types of memory: (1) fixed and (2) erasable. The fixed memory permanently stores navigation tables, trajectory parameters, programs, and constants. The erasable memory stores intermediate information.

The CMC processes data and issues discrete control signals, both for the PGNCS and the other spacecraft systems. It is a control computer with many of the features of a general purpose computer. As a control computer, the CMC aligns the stable platform of the IMU in the inertial subsystem, positions the optical unit in the optical subsystem, and issues control commands to the spacecraft. As a general purpose computer, the CMC solves guidance problems required for the spacecraft mission.

The DSKYs facilitate intercommunication between the flight crew and the CMC. The DSKYs operate in parallel, with the main display console DSKY providing CMC display and control while the crew are in their couches. (See Figure A-2).

The exchange of data between the flight crew and the CMC is usually initiated by crew action; however, it can also be initiated by internal computer programs. The exchanged information is processed by the DSKY program. This program allows the following four different modes of operations:

a. Display of Internal Data - Both a one-shot display and a periodically updating display (called monitor) are provided.

b. Loading External Data - As each numerical character is entered, it is displayed in the appropriate display panel location.

c. Program Calling and Control - The DSKY is used to initiate a class of routines which are concerned with neither loading nor display. Certain routines required instructions from the operator to determine whether to stop or continue at a given point.

d. Changing Major Mode - The initiation of large scale mission phases can be commanded by the operator.

The data involved in both loading and display can be presented in either octal or decimal form as the operator indicates. If decimal form is chosen, the appropriate scale factors are supplied by the program. Decimal entries are indicated by entering a sign (+ or -).

Keyboard Operation. The basic language of communication between the operator and the CMC is a pair of functions designated as verbs and nouns. Each of these is represented by a two-character octal number. The verb code indicates what action is to be taken (operation); the noun code indicates to what action is applied (operand). Typical verbs are those for displaying and loading. Nouns usually refer to a group of erasable registers within the computer memory. The PROGRAM, VERB, and NOUN displays provide two digit numbers which are coded numbers describing the action being performed. The REGISTER 1, 2, and 3 displays provide display of the contents of registers or memory locations. These displays are numbers which are read as decimal numbers if a sign (+ or -) is present and octal numbers if no sign is used. The REGISTER displays operate under program desired. The crew may request display of the contents of a specific register or memory location by commanding the display from the keyboard. The only other displays are the ACTIVITY lights which indicate whether the computer is computing or accepting telemetry from MSFN.

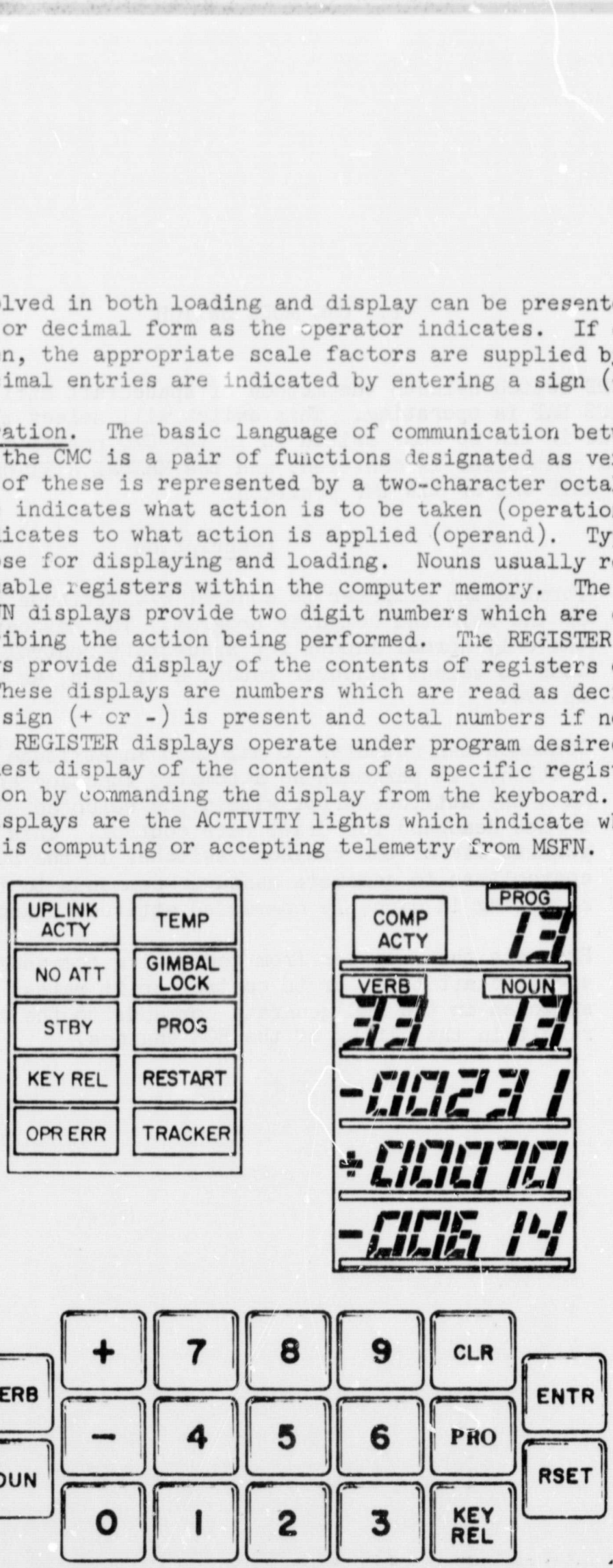


Figure A-2 Display and Keyboard

1. CMC MODE SWITCH

The CMC MODE switch selects the method of spacecraft attitude control when the RCS DAP is operating. This switch will select the CMC S/C control mode if the SC CONT switch is in the CMC position, the translational hand controller is centered, and the MANUAL ATTITUDE switches are in the RATE CMD or MIN IMP position.

Position	Description
AUTO	Permits the computer to control S/C attitude as a function of the selected computer program. The keyboard inputs are the only normal inputs for spacecraft control and may be used to select maneuver rates, attitudes, as well as set up TVC.
HOLD	Commands the computer to maintain an attitude hold configuration. It performs no automatic function except to maintain the attitude error within the selected deadband with a rate deadband for drift rate control. This position permits use of the breakout switches in the SCS rotational controllers to generate maneuver commands to the computer resulting in manually commanded attitude change.
FREE	Prevents the computer from generating commands to maintain specific attitudes or to control drift rates. The breakout switches in the RHC generate commands to the computer that result in the firing of the RCS engines.

2. CMC ATT SWITCH

This switch should normally remain in the IMU (UP) position throughout the mission. This position assumes normal operation of the G&N system to perform all control functions. In the GDC (DOWN) position, a discrete logic signal to the computer indicating IMU failure inhibits all command outputs from the computer for attitude control. The SCS would then be used to control spacecraft attitude if the IMU failed.

C. SERVICE PROPULSION SYSTEM

The SPS provides the impulse for all major velocity changes throughout a mission including the nominal deorbit burn. The system incorporates displays and sensing devices to permit earth-based stations as well as the crew to monitor its operation.

The engine assembly is mounted to the SM structure. It is gimbaled to permit thrust vector alignment through the center of mass prior to thrust initiation and thrust vector control during a thrusting period. A flight combustion stability monitor system with manual override is employed to monitor engine performance through the SCS thrust control logic if automatic thrust control is used. If the FCSM removes SPS thrust, the caution and warning system will cause the SPS ROUGH ECO light to illuminate.

1. DIRECT ULLAGE PUSH BUTTON

When the button is depressed, a +X translation utilizing all four quads is commanded. This is the backup method for ullage maneuvers prior to an SPS burn (the prime method for ullage is the translational controller). The DIRECT ULLAGE switch is momentary and must be held until ullage is complete. It will not provide rate damping, however, since the pitch and yaw automatic coils are disengaged.

2. THRUST ON PUSH BUTTON

The THRUST ON push button can be used to start the SPS engine under the following conditions:

a. SCS control mode selected

b. Ullage is provided

c. ΔV THRUST switches (either of two) are in the NORMAL position
NOTE: Both must be OFF to shut off the engine.

The SPS engine can be shut off (when fired as described above) in the following manner:

1. FCSM shuts it down automatically

2. ΔV COUNTER = 0 (SCS or MTVC)

3. ΔV THRUST switches (both) OFF

The SPS THRUST light located in the EMS will illuminate when the engine valve solenoids receive a ground path, completing the thrust on circuit.

3. SPS THRUST DIRECT ON/NORMAL

The switch is a two position lever lock toggle type. The ON position provides a ground for the solenoid valve power and the associated SCS logic. The engine must be turned off manually by removing prevalve power as no automatic shutoff exists. At least one ΔV THRUST switch must be in the NORMAL position to apply power to the solenoids for the SPS THRUST DIRECT switch to operate.

WARNING

The SPS THRUST DIRECT switch is a single point failure when the ΔV THRUST switches are in the NORMAL position.

4. SPS GIMBAL MOTORS/INDICATORS

There are four gimbal motors used to control the SPS engine position in the pitch and yaw planes (two in each plane). These motors are activated by four switches located on panel 1. The motors should be activated one at a time due to high current drain during start.

The gimbal thumbwheels can be used to position the gimbals to the desired angle as shown on the gimbal position indicators when the SPS is under SCS control. The indicators are analog displays time shared with the booster fuel and oxidizer pressure readings. The desired display can be selected by the switch located at the bottom of panel 1.

Other methods of controlling the gimbal position are by the rotational hand controller in the MTVC mode or by automatic SCS logic.

5. ΔV THRUST (PREVALVES AND LOGIC)

The two guarded switches apply power to the SPS solenoid prevalves and to the SCS logic for SPS ignition. These switches must be on (NORMAL) before the SPS engine can be started--even by the SPS THRUST DIRECT switch.

WARNING

Either switch enabled will enable engine start, however, both must be OFF to stop the engine.

6. SCS THRUST VECTOR CONTROL

These switches are active only in the SCS mode.

Pitch and yaw channels can be used independently; i.e., pitch control could be in SCS automatic and yaw in MTVC. The three available modes are:

a. AUTO: The TVC is directed by the SCS electronics

b. RATE CMD: MTVC with rate damping included

c. ACCEL CMD: MTVC without rate damping

7. ΔV AND ΔV SET SWITCHES

In order for the ΔV counter to operate during an SPS burn, the switches located on the EMS panel must be in the following positions:

a. EMS MODE - AUTO

b. EMS FUNCTION - ΔV

To set the ΔV counter for a desired ΔV burn the switches would be as follows:

a. EMS MODE - STANDBY

b. EMS FUNCTION - ΔV SET

The five position ΔV SET slew switch is then used to place the desired quantity on the ΔV display.

D. STABILIZATION AND CONTROL SYSTEM

The SCS provides a capability for crewmembers to control rotation, translation, attitude reference, and thrust vector control by manual or automatic selection. Displays are provided to monitor the control modes selected. All control functions in this system are backup to the Primary Guidance, Navigation and Control Subsystem.

1. SCS CHANNEL SWITCHES

These switches are used to apply power to or remove power from the RCS Control Box Assembly. Power is also removed from the attitude control logic by these switches, thereby deleting all automatic attitude hold and/or maneuvering capability using SCS electronics. The DIRECT solenoids are not affected as all SCS electronics are bypassed by activation of the DIRECT RCS switch (manual control).

NOTE: The automatic solenoids cannot be activated until the RCS enable is activated either by the MESC or manually.

2. DIRECT RCS SWITCH

The DIRECT RCS switch provides manual control of the SM RCS engines. The control is achieved by positioning the rotation control hardover to engage the DIRECT solenoids for the desired axis change.

All SCS electronics are bypassed when this switch is activated.

3. ATT SET SWITCH

Selects the source of total attitude for the ATT SET resolvers.

Position	Function	Description
UP	IMU	Applies IMU gimbal resolver signal to ATT SET resolvers. FDAI error needles display difference. Needles are zeroed by maneuvering S/C or by moving the ATT SET dials.
DOWN	GDC	Applies GDC resolver signal to ATT SET resolvers. FDAI error needles display differences resolved into body corrdinates. Needles zeroed by moving S/C or ATT SET dials. New attitude reference is established by depressing GDC ALIGN button. This causes GDC to drive to null the error; hence, the GDC and ball go to ATT SET dial value.

4. MANUAL ATTITUDE SWITCHES

These three switches (ROLL, PITCH, and YAW) are only operative when the S/C is in the SCS mode of operation.

Position	Description
ACCEL CMD	Provides direct RCS firing as a result of moving the rotational controller out of detent (2.5^{o}) to apply direct inputs to the solenoid driver amplifiers.
RATE CMD	Provides proportional rate command from rotational controller with inputs from the BMAG's in a rate configuration.
MIN IMP	Provides minimum impulse capability through the rotational controller.

5. LIMIT CYCLE

The pseudo-rate function provides the capability of maintaining low S/C rates while holding the S/C attitude within the selected deadband limits (limit cycling). This is accomplished by pulse-width modulation of the switching amplifier outputs. Instead of driving the S/C from limit to limit with high rates by firing the RCS engines all the time, the engines are fired in "spurts" proportional in length and repetition rate to the switching amplifier outputs.

Extremely small attitude corrections could be commanded which would cause the pulse width of the resulting output command to be of too short a duration to activate the RCS solenoids. A "one-shot" multivibrator is connected in parallel to insure a long enough pulse to fire the engines.

6. RATE AND ATT DEADBAND SWITCHES

The switching amplifier deadband can be interpreted as a rate or an attitude (minimum) deadband. The deadband limits are a function of the RATE switch. An additional deadband can be enabled in the attitude control loop with the ATT DEADBAND switch.

RATE Switch Position	Rate Deadband °/sec	ATT DEADBAND Switch Position Min	Max
LOW	±0.2	±0.2°	±4.2°
HIGH	±2.0	±4.0°	±8.0°

The rate commanded by a constant stick deflection (Proportional Rate Mode only) is a function of the RATE switch position. The rate commanded at maximum stick deflection (soft stop) is shown below:

RATE Switch Position	Maximum Proportional Rate Command	
	Pitch and Yaw	Roll
LOW	0.65°/sec	0.65°/sec
HIGH	7.0 °/sec	20.0 °/sec

7. S/C CONTROL (SOURCE)

Position	Description
CMC	Selects the G and N system - computer controlled S/C attitude and TVC through the digital autopilot. An autopilot control discrete is also applied to CMC.
SCS	The SCS controls the S/C attitude and the TVC.

8. BMAG MODE - ROLL, PITCH, AND YAW

Selects displays for the FDAI using SCS inputs.

Position	Description
RATE 2	BMAG Set No. 2 provides the rate and attitude displays on the FDAI. There is no BMAG attitude error reference available.
ATT 1/ RATE 2	BMAG Set No. 1 provides attitude error needles on the FDAI, while Set No. 2 provides the rate display and attitude.
RATE 1	BMAG Set No. 1 provides the rate and attitude displays on the FDAI. There is no BMAG attitude error reference available.

9. EMS ROLL SWITCH

This switch enables the EMS roll display for the earth reentry phase of the flight.

10. 0.05 G SWITCH

Illumination of the 0.05 G light located on the EMS panel is the cue for the crew to actuate the 0.05 G switch. During atmospheric reentry, the S/C is maneuvered about the stability roll axis rather than the body roll axis. Consequently, the yaw rate gyro generates an undesirable signal. By coupling a component of the roll signal into the yaw channel, the undesirable signal is cancelled. The 0.05 G switch performs this coupling function.

11. GDC ALIGN SWITCH

The GDC ALIGN switch is a momentary contact push button which must be held depressed for performance of the aligning function. Utilizing error signals derived from a difference of the attitude set resolvers and the total attitude resolvers of the GDC, the latter can be repositioned until they are aligned to the selected numbers on the thumbwheels. If an FDAI is displaying the GDC total attitude, it will drive as the alignment is accomplished. If the derived error (difference between the GDC and ATT SET) is displayed, the needles will zero as the alignment is commanded.

E. ENTRY MONITOR SYSTEM

The Entry Monitor System (EMS) provides a visual monitor of automatic Primary Guidance, Navigation and Control System (PGNCS) entries and delta velocity maneuvers. It also provides sufficient display data to permit manual entries in event of PGNCS malfunctions and automatic delta velocity cutoff SCS commands when controlling the SPS engine. The delta velocity display can also be used as the cue to initiate manual thrust off commands for malfunctions of the automatic commands.

Self test provisions are provided by a function switch for both operational modes (Entry and Delta V) to provide maximum system confidence prior to actual use. Only the items and their functions related to entry will be discussed in this document.

The front panel of the EMS is shown in Figure A-3. It provides six displays and/or indications that are used to monitor automatic entry or perform manual entry. In addition there are four switches to activate and select the desired function in the EMS.

1. THRESHOLD INDICATOR (0.05 G)

The indicator, labeled 0.05 G, provides a visual indication of deceleration. The altitude at which this indicator is illuminated is a function of entry angle (velocity vector with respect to local horizontal), the magnitude of the velocity vector geographic location and heading, and atmospheric conditions. It is illuminated when an acceleration of 0.05 G $\pm$ 0.005 G is sensed and turns off when the acceleration drops below 0.02 G $\pm$ 0.002 G.

2. ROLL STABILITY INDICATOR

The Roll Stability Indicator (RSI) provides a roll reference about the stability axis with respect to some prealigned position. When properly aligned, it provides a visual indication of the lift vector attitude of the CM about the velocity vector. The needle-up position (0 degree) indicates a maximum lift vector up condition, and the needle-down position (180 degrees) a maximum lift vector down condition.

3. CORRIDOR VERIFICATION INDICATORS

By sensing the g-force buildup, comparator circuits determine whether the venicle entry angle is steep enough to avoid superorbital skipout. If the acceleration level is greater than 0.2 g at the end of 10 seconds after threshold, the upper light on the RSI will light. If the g-value is equal to or less than this value, the lower light will light. Either light remains illuminated until the acceleration level reaches 2.0 g at which time they are extinguished regardless of subsequent g-loads. The corridor verification indicators have no significance on earth orbital missions.

4. RANGE AND ΔV DISPLAYS

This instrument is a single electronic alpha numeric counter used for two types of displays, Range and ΔV.

a. Range Display - The Range Display is a readout of inertial flight path distance in nautical miles to the predicted splashpoint after 0.05 g. The predicted range will be obtained from the PGNCS or MCC (MCC prime) and inserted into the counter during EMS range set prior to entry.

b. ΔV Display - The predicted ΔV obtained from the PGNCS or MCC will also be inserted into the counter during EMS ΔV set prior to powered maneuvers (SPS or RCS). The display will indicate ΔV (feet/second) during thrusting.

5. FLIGHT MONITOR (G-V PLOTTER)

The flight monitor scribe provides an entry trace of g versus inertial velocity (x body axis g level versus inertial velocity, Figure A-3). The mylar scroll has printed guidelines which provide monitor (or control) information during aerodynamic entry. The entry trace is generated by driving a scribe in a vertical direction as a function of g level, while the mylar scroll is driven from right to left proportional to the CM inertial velocity change. Monitor and control information for safe entry and range potential can be observed by comparing the slope of entry trace to the slope of the nearest guidelines (g on set, g off set, and ranging lines). g off set lines for earth orbital missions will not be used.

6. ENTRY SCROLL

The EMS entry pattern (Figure A-3) contains inertial velocity V and load factor g, scales as well as entry guidelines. The entry guidelines are g on set, g off set, and range potential lines (1, 2, 3 from Figure A-3). A detailed procedure with the use of these guidelines for an entry trace is discussed on page A-21. The vertical line of the scroll at 25,500 FPS (4 from Figure A-3) is where the CM velocity becomes suborbital. The full positive lift profile line (5 from Figure A-3) represents the steady state minimum g entry profile.

7. MODE SWITCH

The MODE switch has three positions: STBY, AUTO, and MAN. The STBY position applies power to the EMS circuits; it inhibits system operation but does not inhibit set functions. The AUTO position permits the self tests to function. It also is the normal position for operations with the FUNCTION switch in the ENTRY or ΔV positions. The MAN position is used as a backup to initiate the scroll velocity drive and the range display countdown in the event of failure of the 0.05 G circuits. The MAN position energizes the 0.05 G light, but does not activate the corridor verification circuits for a display.

8. FUNCTION SWITCH

The FUNCTION switch is a 12 position switch which is used to select the desired function in the EMS. Three positions are used for ΔV operations. Eight positions are used for entry, entry set, and self test. The remaining position is off.

Position	Description
OFF	Deactivates the EMS except the SPS THRUST ON light and the RSI
Test 1	Tests lower trip point of 0.05 G - threshold comparator and enables slewing of the scroll
Test 2	Tests the high trip point of the 0.05 G threshold comparator
Test 3	Tests lower trip point of the corridor verification comparator and enables slewing of the ΔV/range display for EMS Test 4 operations. It also initializes the range integrator to 37,000 fps.
Test 4	Tests the range-to-go integrator circuits, G servo circuits, G-V plotter and range-to-go circuits
Test 5	Test high trip point of corridor verification comparator and enables slewing of scroll to the start of an entry pattern.
RNG SET	Establishes circuitry for slewing the ΔV/range display
Vo SET	Establishes circuitry for slewing the scroll to the predicted inertial velocity at 0.05 G. The scroll should be set at 37,000 fps for the start of this setting. Range value must be set before slewing the scroll away from 37,000 fps.
ENTRY	Operational position for self test of ΔV circuits
ΔV TEST	Operational mode for self test of ΔV subsystem
ΔV SET	Establishes circuitry for slewing the ΔV/range display
ΔV	Operational position for accelerometer to drive the ΔV/range display for X axis accelerations.

9. ▲V/EMS SET SWITCH (SLEW SWITCH)

The ▲V/EMS SET switch is a rocker-type control used to preset ▲V thrust, initial range-to-go, and initial velocity requirements. Pressure at the top of the switch will cause the applicable function to increase in magnitude; pressure at the bottom of the switch will cause a decrease. The rocker switch has five positions: null, slow positive, fast positive, slow negative, and fast negative. The slow positive and slow negative rates are achieved by pressing the top or bottom (respectively) of the rocker switch into the soft stops. The fast rates are achieved by pressing the switch through the soft stops to the hard stops.

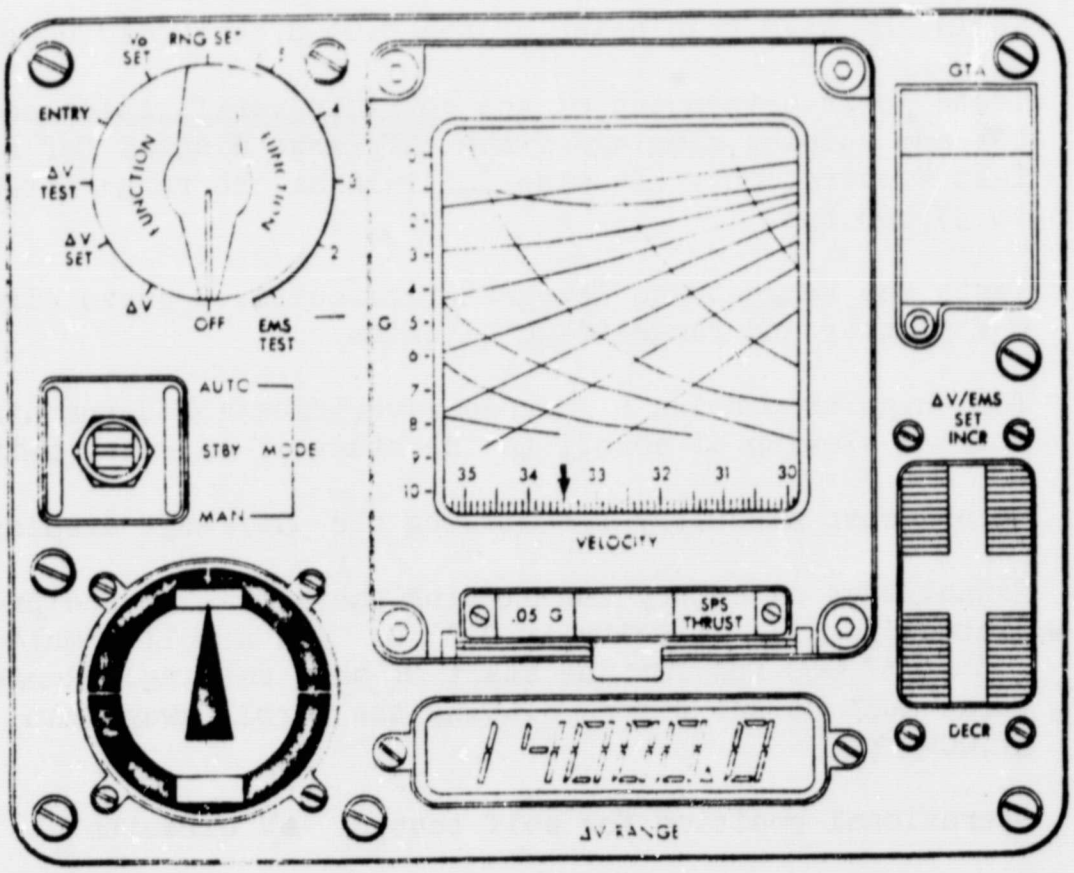


Figure A-3 Entry Monitor System Control Panel

10. USE OF THE EMS

The EMS grid consists of two sets of lines, one for the supercircular portion of the entry and the other set for the subcircular portion of the entry. The supercircular portion (inertial velocity between approximately 37,000 FPS and 25,500 FPS) contains g on set, g off set lines and the potential range lines (Figure A-4).

The subcircular portion (inertial velocity between approximately 25,500 FPS and 4,000 FPS) will be used for Spacecraft 101. It contains g on set lines and the potential range lines. The g on set lines slope downward from left to right. The potential range lines begin at an inertial velocity of approximately 25,500 FPS and continue to the end of the scroll (4,000 FPS). These range lines are marked every few inches with numbers (8, 6, 5, 3, 2, 1.5, 1.0, 0.5) which represent hundreds of miles to go to target. These lines indicate to the pilot how much farther the spacecraft will travel if the pilot holds the present g level constant.

The pilot will receive an EMS update prior to entry consisting of inertial velocity, RTGO from sensed 0.05 g to 25,000 feet, RTGO from 0.05 g altitude (about 283,000 feet), cross range to the right or left of the target, bank angle, and time to reverse bank angle. He will slew the EMS scroll to the correct inertial velocity and the RTGO from the 0.05 g altitude in the RTGO meter. For the EMS entry the pilot should use the following technique:

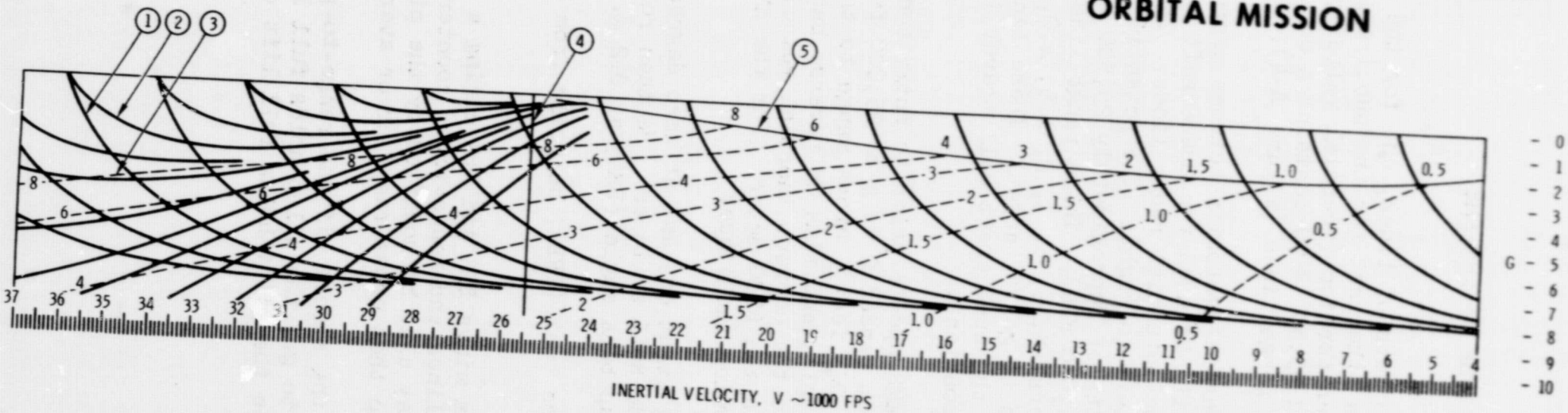
a. At 0.05 g (0.05 g light on) and at zero degrees roll, the pilot turns on the 0.05 g and EMS ROLL switches. He then rolls from zero degrees to the minus backup bank angle (BBA) at 0.2 g.

b. At time to reverse bank (TRB), he rolls from minus BBA to plus BBA.

c. The pilot adjusts minus BBA and BBA during a and b above so that the range potential lines and range-to-go counter are in agreement. The value of TRB may also be modified by the pilot to compensate for adjustments in BBA, so that cross range error averages out.

d. At 4,000 FPS on the scroll, if the range-to-go counter reads more than 27 (TBD) miles to go, the pilot holds full lift up until drogues deploy. Otherwise the pilot holds full lift down.

NON-EXIT ENTRY PATTERN FOR EMS ORBITAL MISSION



1. ON-SET GUIDE LINE
2. OFF-SET GUIDE LINE
3. RANGE POTENTIAL GUIDE LINE
4. SATELLITIC VELOCITY INDICATOR
5. FULL LIFT PROFILE

Figure A-4 Entry Scroll Pattern

F. COMPUTER VERB LIST

REGULAR VERBS
01 DISPLAY OCTAL COMP 1, IN R1
04 DISPLAY OCTAL COMP 1, w IN R1, R2
05 DISPLAY OCTAL COMP 1, 2, 3 IN R1, R2, R3
06 DISPLAY DECIMAL IN R1 OR R1, R2 OR R1, R2, R3
16 MONITOR DECIMAL IN R1 OR RL, R2 OR R1, R2, R3
21 LOAD COMP 1 INTO R1
24 LOAD COMP 1, 2 INTO R1, R2
25 LOAD COMP 1, 2, 3 INTO R1, R2, R3
33 PROCEED WITHOUT DSKY INPUTS
34 TERMINATE FUNCTION
37 CHANGE PROGRAM (MAJOR MODE)

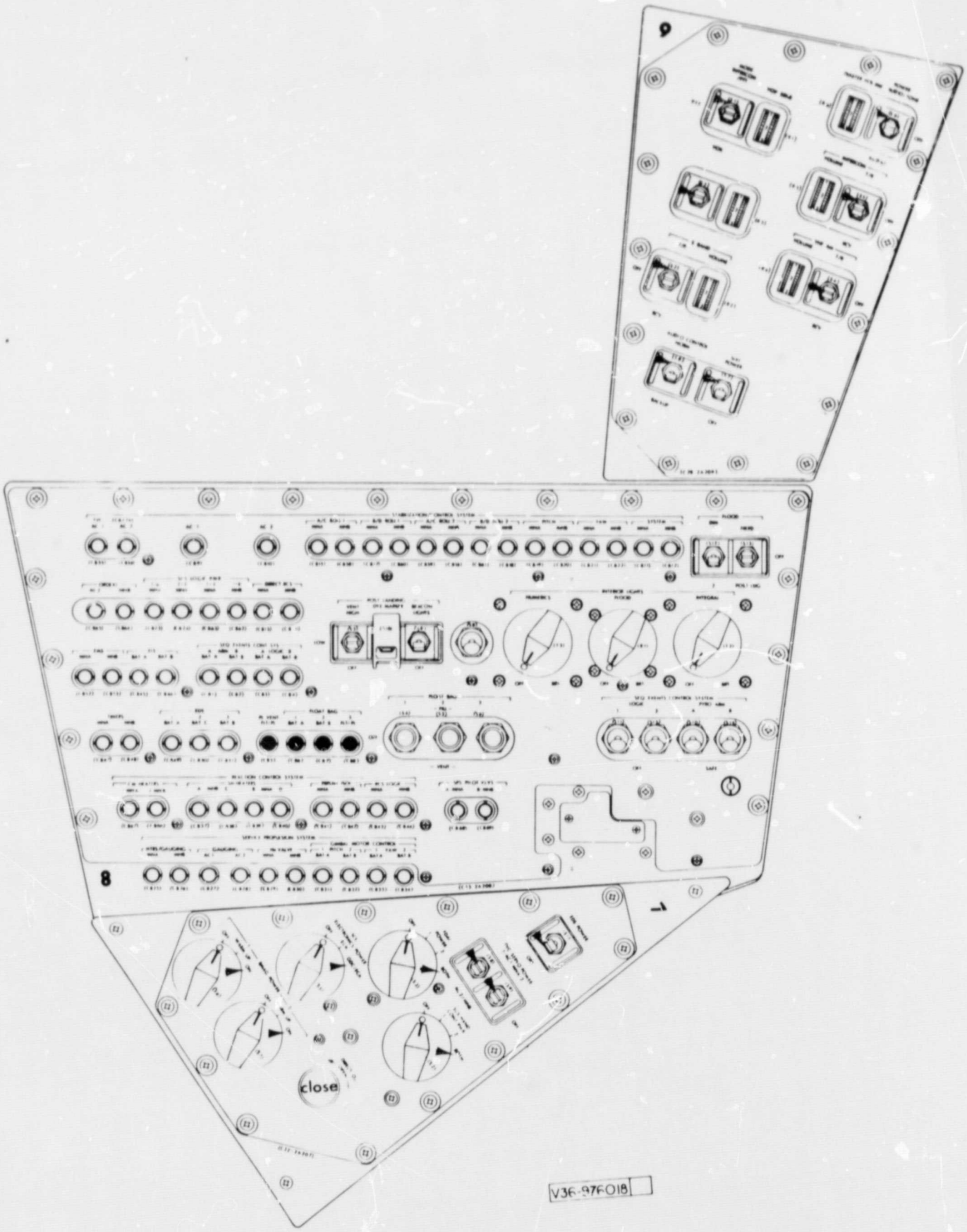
EXTENDED VERBS
50 PLEASE PERFORM
51 PLEASE MARK
70 UPDATE LIFT-OFF TIME
71 UNIVERSAL UPDATE-BLOCK ADR (P27)
72 UNIVERSAL UPDATE-SINGLE ADR (P27)
73 UPDATE CMC TIME (OCTAL) (P27)

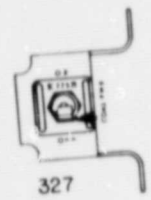
G. COMPUTER NOUN LIST

NOUNS	DESCRIPTION	SCALE AND FORMAT	UNITS
01	SPECIFY ADDRESS (FRAC)	.XXXX	FRACTION
		.XXXXX	FRACTION
		.XXXXX	FRACTION
02	SPECIFY ADDRESS (WHOLE)	XXXXX.	INTEGER
		XXXXX.	INTEGER
		XXXXX.	INTEGER
05	ANGULAR ERROR/DIFF	XXX.XX	DEG
06	OPTION CODE ID	OCTAL	
	OPTION CODE		
07	CHANGE OF PROGRAM (R1) (USED WITH V50)	XXXXX.	
09	ALARM CODES	OCTAL	
19	ENABLE TRIM	XXX.XX	DEG
	(USED WITH V50 ONLY)	XXX.XX	DEG
	(RETAINS N22 DISPLAYS)	XXX.XX	DEG
22	NEW ICDU ANGLES, ROLL	XXX.XX	DEG
	PITCH	XXX.XX	DEG
	YAW	XXX.XX	DEG
25	CHECKLIST CODES	XXXXX.	
	(USED WITH V50)	BLANK	
		BLANK	
32	TIME TO PERIGEE	00XXX.	HRS
		000XX.	MIN
		0XX.XX	SEC
33	TIME OF IGNITION (GETI)	00XXX.	HRS
		000XX.	MIN
		0XX.XX	SEC
35	TIME FROM EVENT	00XXX.	HRS
		000XX.	MIN
		0XX.XX	SEC
40	TF GETI/TFC	XXBXX.	MIN-SEC
	TG	XXXX.X	FPS
	DELTA V (ACCUMULATED)	XXXX.X	FPS
42	APOGEE ALT	XXXX.X	NM
	PERIGEE ALT	XXXX.X	NM
	ΔVR	XXBXX.	FPS
44	APOGEE ALT	XXXX.X	NM
	PERIGEE ALT	XXXX.X	NM
	TFF	XXBXX.	MIN--SEC
45	MARKS	XXXXX.	
	TF GETI OF NEXT BURN	XXBXX.	MIN--SEC
	MGA	XXX.XX	DEG
46	AUTOPILOT CONFIG (R1 AND R2)	OCTAL	
47	IX	XXXXX.	SLUG-FT SQ
	(IY + IZ)/2	XXXXX.	SLUG-FT SQ
48	PITCH TRIM	XXX.XX	DEG
	YAW TRIM	XXX.XX	DEG
	TLX	XXXXX.	FT-LBS

G. COMPUTER NOUN LIST (continued)

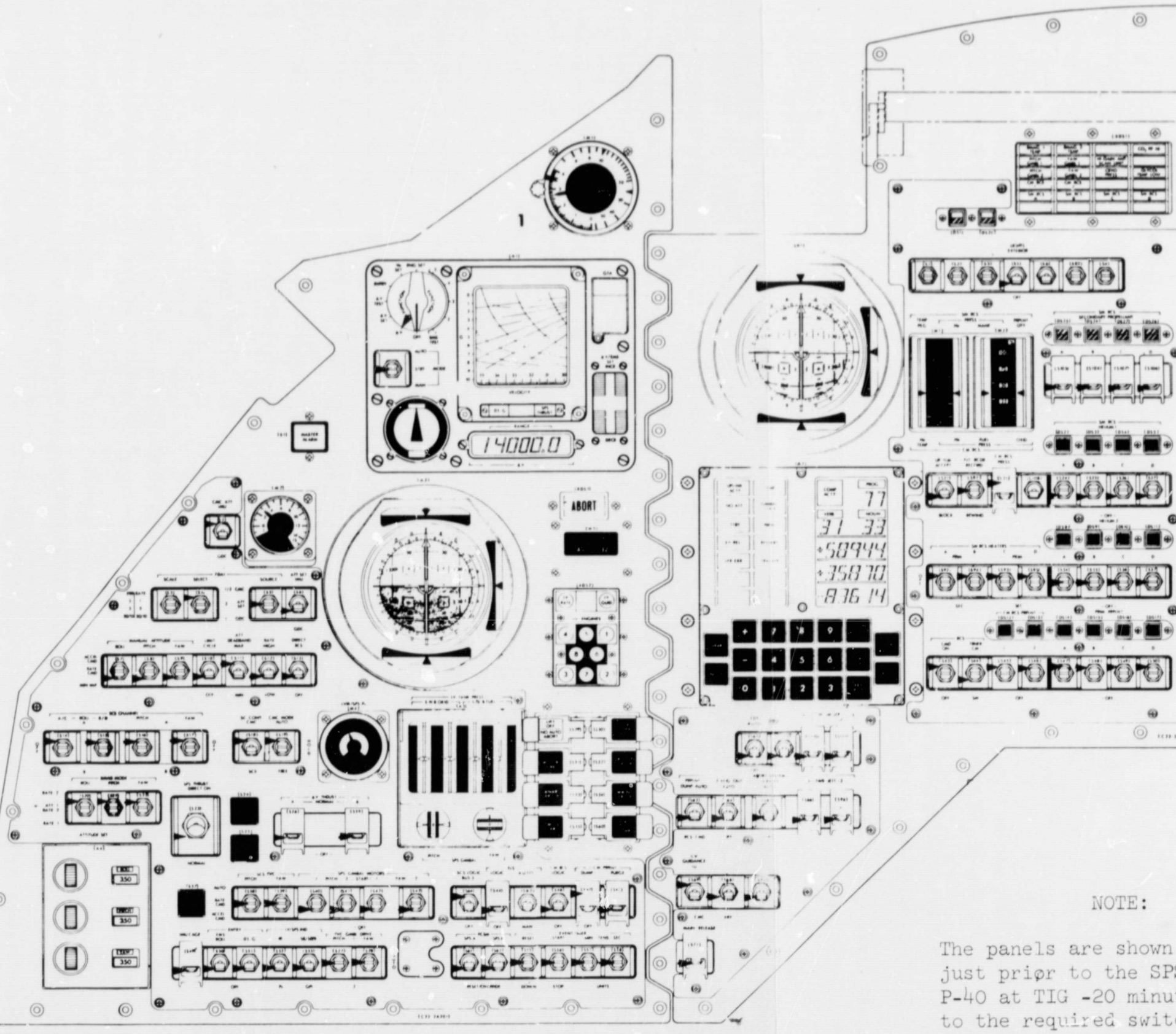
60	G MAX	XXX.XX	G
	V PRED	XXXXX.	FPS
	GAMMA EI	XXX.XX	DEG
61	IMPACT LAT	XXX.XX (+ NORTH)	DEG
	IMPACT LONG	XXX.XX (+ EAST)	DEG
	HEAD UP/DOWN	+/-00001 (+ HEADS UP)	
63	RTGO-RNG 297,431 FT TO SPLASH	XXXX.X	NM
	VIO-PREDICTED INERTIAL VELOCITY	XXXXX.	FPS
	TTE-TIME FROM 297,431 FT	XXBXX.	MIN-SEC
64	DRAG ACCELERATION	XXX.XX	G
	VI, INERTIAL VELOCITY	XXXXX.	FPS
	RTGO, RANGE TO SPLASH	XXXX.X	NM
66	BETA, CMD BANK ANGLE	XXX.XX	DEG
	CROSS RANGE ERROR	XXXX.X (+ RIGHT)	NM
	DOWN RANGE ERROR	XXXX.X (+ OVERSHOOT)	NM
67	RTGO, RANGE TO TARGET	XXXX.X (+ OVERSHOOT)	NM
	LAT, PRESENT POSITION	XXX.XX (+ NORTH)	DEG
	LONG, PRESENT POSITION	XXX.XX (+ EAST)	DEG
68	BETA, CMD BANK ANGLE	XXX.XX	DEG
	VI, INERTIAL VEL	XXXXX.	FPS
	H DOT ALT RATE CHANGE	XXXXX.	FPS
70	STAR DATA	OCTAL	
	LMK DATA	OCTAL	
	HORIZ DATA	OCTAL	
82	DELTA VX (LV)	XXXX.X	FPS
	DELTA VY (LV)	XXXX.X	FPS
	DELTA VZ (LV)	XXXX.X	FPS
85	VGX (BODY CONTROL AXIS)	XXXX.X	FPS
	VGY (BODY CONTROL AXIS)	XXXX.X	FPS
	VGZ (BODY CONTROL AXIS)	XXXX.X	FPS
86	VGX (LV)	XXXX.X	FPS
	VGY (LV)	XXXX.X	FPS
	VGZ (LV)	XXXX.X	FPS
92	NEW OCDU (SHAFT)	XXX.XX	DEG
	ANGLES (TRUNNION)	XX.XXX	DEG
93	DELTA GYRO	XX.XXX	DEG
	ANGLES (X,Y,Z)	XX.XXX	DEG
		XX.XXX	DEG





V36-97F018

FOLDOUT FRAME



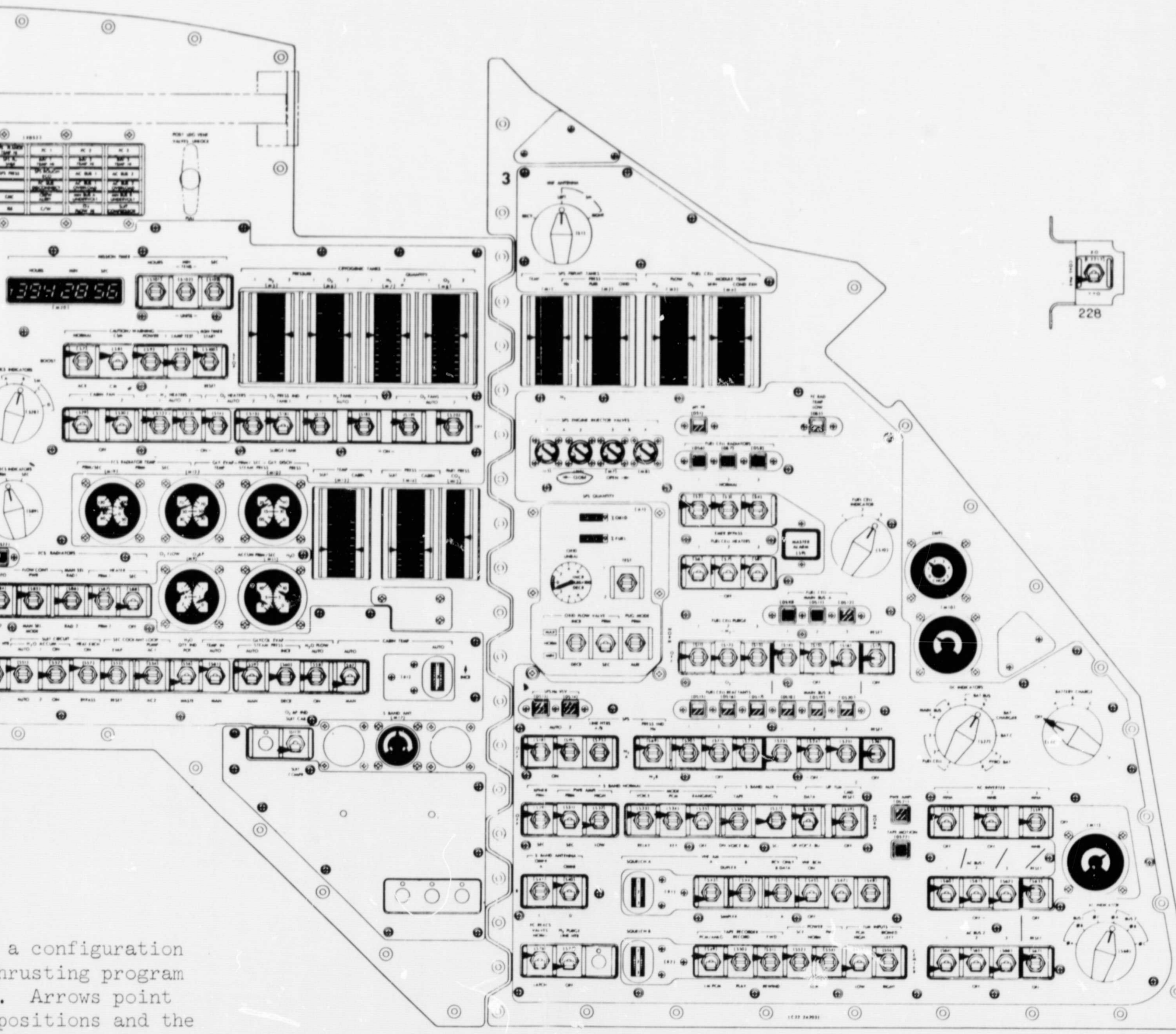
NOTE:

The panels are shown
just prior to the SP
P-40 at TIG -20 minu
to the required swit
circuit breakers are
open position.

Figure A-5 Spacecraft Co

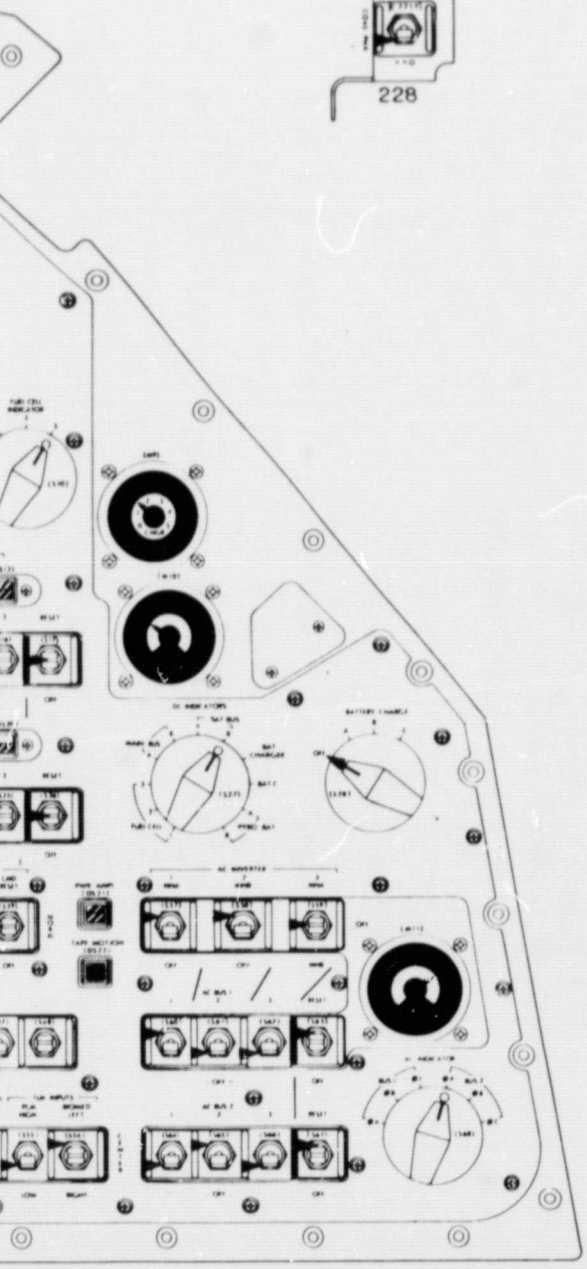
FOLDOUT FRAME 2

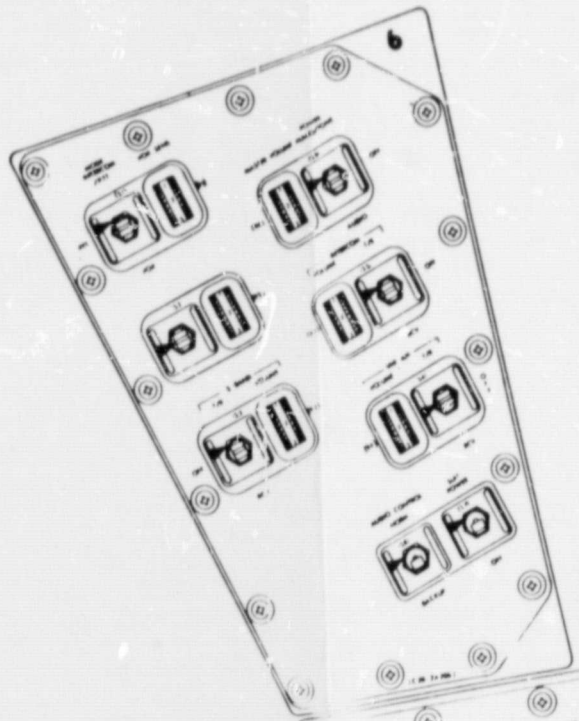
FOLDOUT FRAME

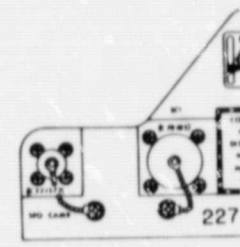


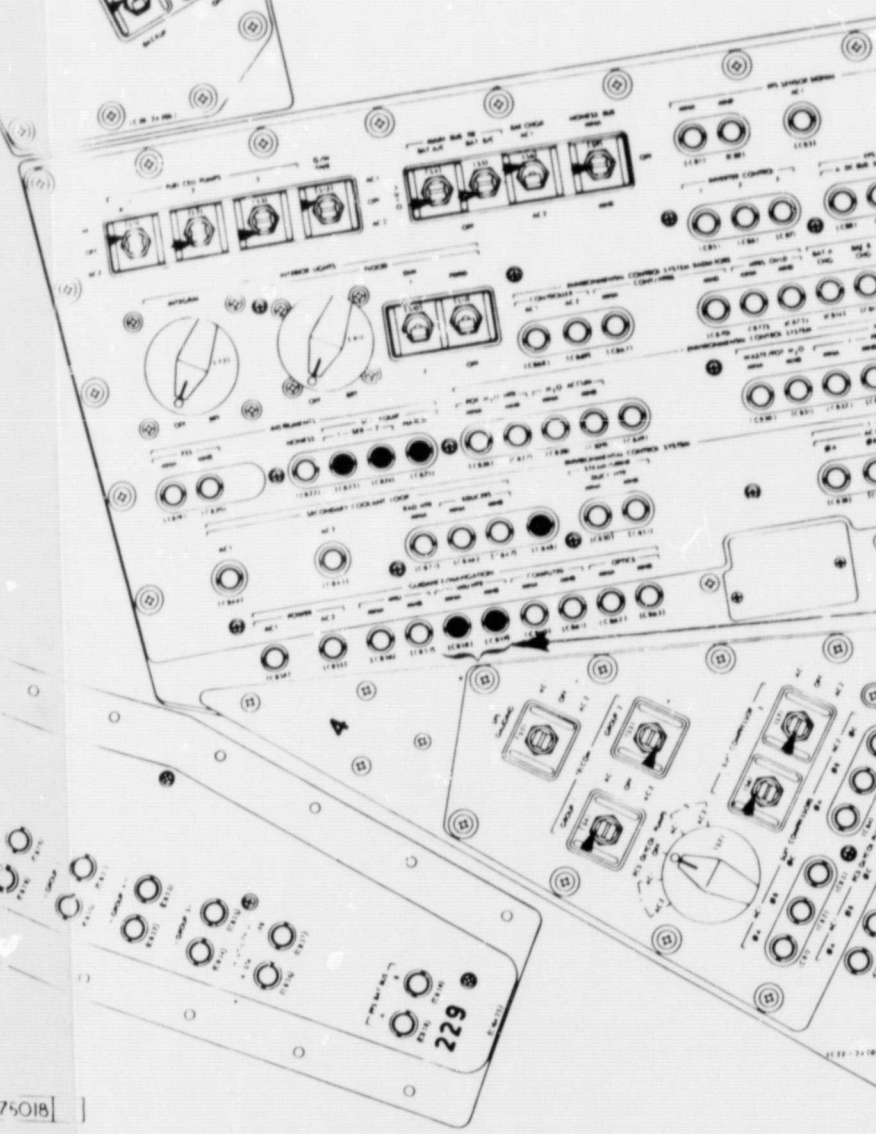
a configuration
nrusting program
. Arrows point
positions and the
aded to show the

ol and Display Panels









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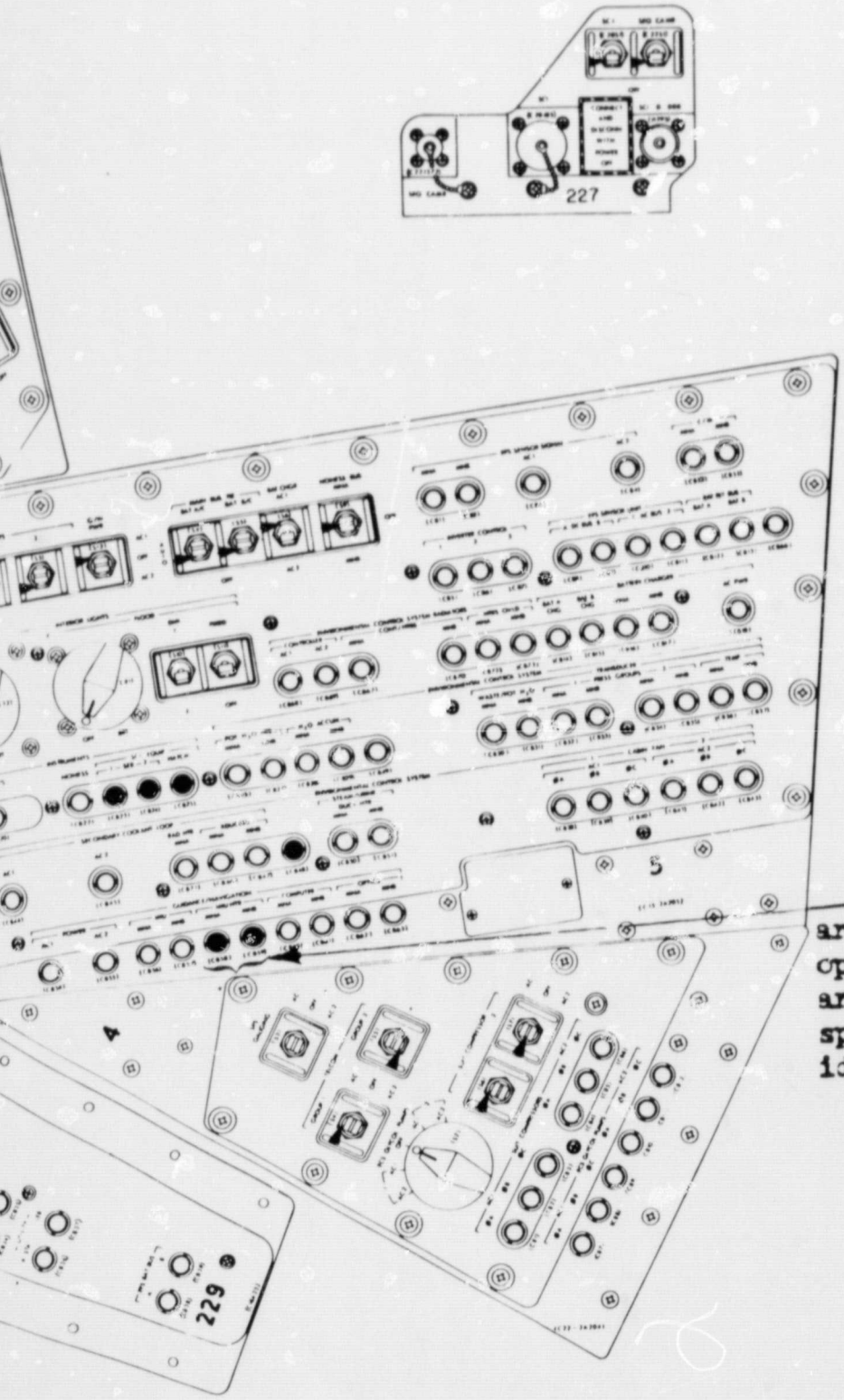
FOLDOUT FRAME 4



IMU/HTR CB's are closed but appear open here because they are colored in the spacecraft for easy identification

FOLDOUT FRAME 5

Appendix B.

Onboard Data Records Used During The Entry Phase

P27 UPDATE

PIRP	V	V	V
GET	: :	: :	: :
01	INDEX __ __	INDEX __ __	INDEX __ __
02			
03			
04			
05			
06			
07			
10			
11			
12			
13			
14			
15			
16			
17			
20			
21			
22			
23			
24			

P27

REMARKS:

NAV CHECK φ λ H T

NAV CHECK φ λ H T

NAV CHECK φ λ H T

P27 UPDATE

PURP	XXX	TYPE OF DATA TO BE RECEIVED (SUCH AS: NAV - LIFT-OFF TIME)
V	XX	TYPE OF COMMAND LOAD (70 - 71 - 72 - 73)
GET	XXX:XX:XX	TIME DATA RECORDED (HR:MIN:SEC)
01	XX	INDEX NO. OF COMMAND WORDS IN LOAD (OCTAL)
02-24	XXXXX	NO. OF CORRECTION COMMAND WORDS
NAV CHECK		TO CONFIRM POINT ABOVE GROUND TRACT FOR A GIVEN TIME
ϕ		LATITUDE
λ		LONGITUDE
H		ALTITUDE
T		TIME

NAVIGATION CHECK

NAV CHECK

			:	:					:	:		GET	N34
X		0		.		X		0		.		LAT	N43
X				.		X				.		LONG	
X	+	0			.	X	+	0			.	ALT	
			:	:					:	:		GET	N34
X		0		.		X		0		.		LAT	N43
X				.		X				.		LONG	
X	+	0			.	X	+	0			.	ALT	
			:	:					:	:		GET	N34
X		0		.		X		0		.		LAT	N43
X				.		X				.		LONG	
X	+	0			.	X	+	0			.	ALT	
			:	:					:	:		GET	N34
X		0		.		X		0		.		LAT	N43
X				.		X				.		LONG	
X	+	0			.	X	+	0			.	ALT	
			:	:					:	:		GET	N34
X		0		.		X		0		.		LAT	N43
X				.		X				.		LONG	
X	+	0			.	X	+	0			.	ALT	
			:	:					:	:		GET	N34
X		0		.		X		0		.		LAT	N43
X				.		X				.		LONG	
X	+	0			.	X	+	0			.	ALT	
X			:	:					:	:		GET	N34
X		0		.		X		0		.		LAT	N43
X				.		X				.		LONG	
X	+	0			.	X	+	0			.	ALT	

NAVIGATION CHECK

SPACECRAFT POSITION DEFINED RELATIVE TO THE EARTH FOR A GIVEN TIME.

GET	XXX:XX:XX	TIME THAT LAT,LONG & ALT VALID (HR:MIN:SEC)
LAT	XX.XX	LATITUDE
LONG	XXX.XX	LONGITUDE
ALT	XXXX.X	ALTITUDE

		PURPOSE	
+ 0 0	+ 0 0	HR GETI	N33
+ 0 0 0	+ 0 0 0	MIN	
+ 0 .	+ 0 .	SEC	
.	.	ΔVX	N82
.	.	ΔVY	
.	.	ΔVZ	
+ 0 .	+ 0 .	HA	N42
0 .	0 .	HP	
+ .	+ .	VC=ΔVR-T.O.	
+	+	WGT	N47
0 0 .	0 0 .	PTRM	N48
0 0 .	0 0 .	YTRM	
X X X :	X X X :	BT(MIN:SEC)	
X X X X	X X X X	SXTS	
X X .	X X .	SFT	
X X X .	X X X .	TRN	
AS REQUIRED			
X X X	X X X	R	
X X X	X X X	P	
X X X	X X X	Y	

MANEUVER

MANEUVER UPDATE

PURPOSE	XXXXXX	TYPE OF MANEUVER TO BE PERFORMED
GETI		TIME OF MANEUVER IGNITION
	XXX	(HR)
	XX	(MIN)
	XX.XX	(SEC)
ΔVX	XXXX.X	EXTERNAL ΔV COMPONENTS
ΔVY	XXXX.X	(USED IN P30)
ΔVZ	XXXX.X	
HA	XXX.X	PREDICTED APOGEE AND PERIGEE ALTITUDES
HP	XXX.X	AFTER MANEUVER
V_C	XXXX.X	PREMANEUVER SETTING IN EMS ΔV COUNTER
W_{GT}	XXXXX	TOTAL VEHICLE WEIGHT
PTRM	X.XX	SPS OFFSETS TO PLACE THRUST
YTRM	X.XX	VECTOR THRU CENTER OF GRAVITY
BT	X:XX	BURN DURATION OF MANEUVER (MIN:SEC)
SXTS	XX	SEXTANT STAR FOR ORIENTATION CHECK (OCTAL)
SFT	XXX.X	SEXTANT SHAFT SETTING FOR ORIENTATION CHECK
TRN	XX.X	SEXTANT TRUNNION SETTING FOR ORIENTATION CHECK
R	XXX	ROLL IGNITION GIMBAL ANGLE
P	XXX	PITCH IGNITION GIMBAL ANGLE
Y	XXX	YAW IGNITION GIMBAL ANGLE

ENTRY UPDATE (PREBURN)		
X -	X -	AREA
X X - .	X X - .	ΔV TO
X X X X X X X X X	X X X X X X X X X	R 400K P 400K Y 400K
+ +	+ +	RTGO .05G 63 VI .05G
X X :	X X :	RET .05G
0 :	0 :	LAT 61 LONG
X X :	X X :	RET .2G DRE 66
R L / X X :	R L / X X :	BANK AN RET RB
X X : X X : X X :	X X : X X : X X :	RETBBO RETEBO RETDROG
ENTRY UPDATE (POSTBURN)		
X X X	X X X	R 400K
+ +	+ +	RTGO .05G 63 VI .05G
X X :	X X :	RET .05G
X X :	X X :	RET .2G DRE 66
R L / X X :	R L / X X :	BANK AN RETRB
X X : X X : X X :	X X : X X : X X :	RETBBO RETEBO RET DROG

ENTRY UPDATE

AREA		XXX.XX	RECOVERY AREA (FIRST 3-LANDING REVOLUTION LAST 2 - RECOVERY AREA AND SUPPORT CAPABILITIES)
ΔV TO		XX.X	TAIL OFF VELOCITY READ IN EMS ΔV COUNTER
R400K		XXX	ROLL ENTRY GIMBAL ANGLE TO ASSURE CAPTURE
P400K		XXX	PITCH ENTRY GIMBAL ANGLE TO ASSURE CAPTURE
Y400K		XXX	YAW ENTRY GIMBAL ANGLE TO ASSURE CAPTURE
RTGO	+	XXXX.X	RANGE TO GO FROM 0.05G TO TARGET
VI	+	XXXXX.	INERTIAL VELOCITY AT 0.05G
RET .05G		XX:XX	TIME FROM RETRO FIRE TO 0.05G (MIN:SEC)
LAT		XX:XX	LATITUDE OF TARGET POINT
LONG		XXXX.XX	LONGITUDE OF TARGET POINT
RET .2G		XX:XX	TIME FROM RETRO FIRE TO 0.2G (MIN:SEC)
DRE		XXXXX.X	DOWN RANGE ERROR AT 0.2G
BANK AN		XX/XX	BACKUP BANK ANGLE SCS TYPE ENTRY (ROLL LEFT/ROLL RIGHT)
RETRB		XX:XX	RET TO REVERSE BACKUP BANK ANGLE (MIN:SEC)
RETBBO		XX:XX	RET TO BEGIN BLACK OUT (MIN:SEC)
RETEBO		XX:XX	RET TO END BLACK OUT (MIN:SEC)
RETDROG		XX:XX	RET TO DROG DEPLOY (MIN:SEC)

ENTRY UPDATE (CONTINUED)

POSTBURN

R 400K	XXX	ROLL ENTRY GIMBAL ANGLE TO ASSURE CAPTURE
RTGO .05G	+XXXX.X	RANGE TO GO FROM 0.05G TO TARGET
VI .05G	+XXXXX.	INERTIAL VELOCITY AT 0.05G
RET .05G	XX:XX	TIME FROM RETROFIRE TO 0.05G (MIN:SEC)
RET .2G	XX:XX	TIME FROM RETROFIRE TO 0.2G (MIN:SEC)
DRE	XXXXX.X	DOWN RANGE ERROR AT 0.2G
BANK AN	XX/XX	BACKUP BANK ANGLE SCS TYPE ENTRY (ROLL LEFT/ROLL RIGHT)
RETRB	XX:XX	RET TO REVERSE BACKUP BANK ANGLE (MIN:SEC)
RETBBO	XX:XX	RET TO BEGIN BLACKOUT (MIN:SEC)
RETEBO	XX:XX	RET TO END BLACKOUT (MIN:SEC)
RETDROG	XX:XX	RET TO DROG DEPLOY (MIN:SEC)

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